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Heating Piping & Air Conditioning

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OCTOBER ★ 1942

...e 623: Journal Section, American Society of Heating and Ventilating Engineers

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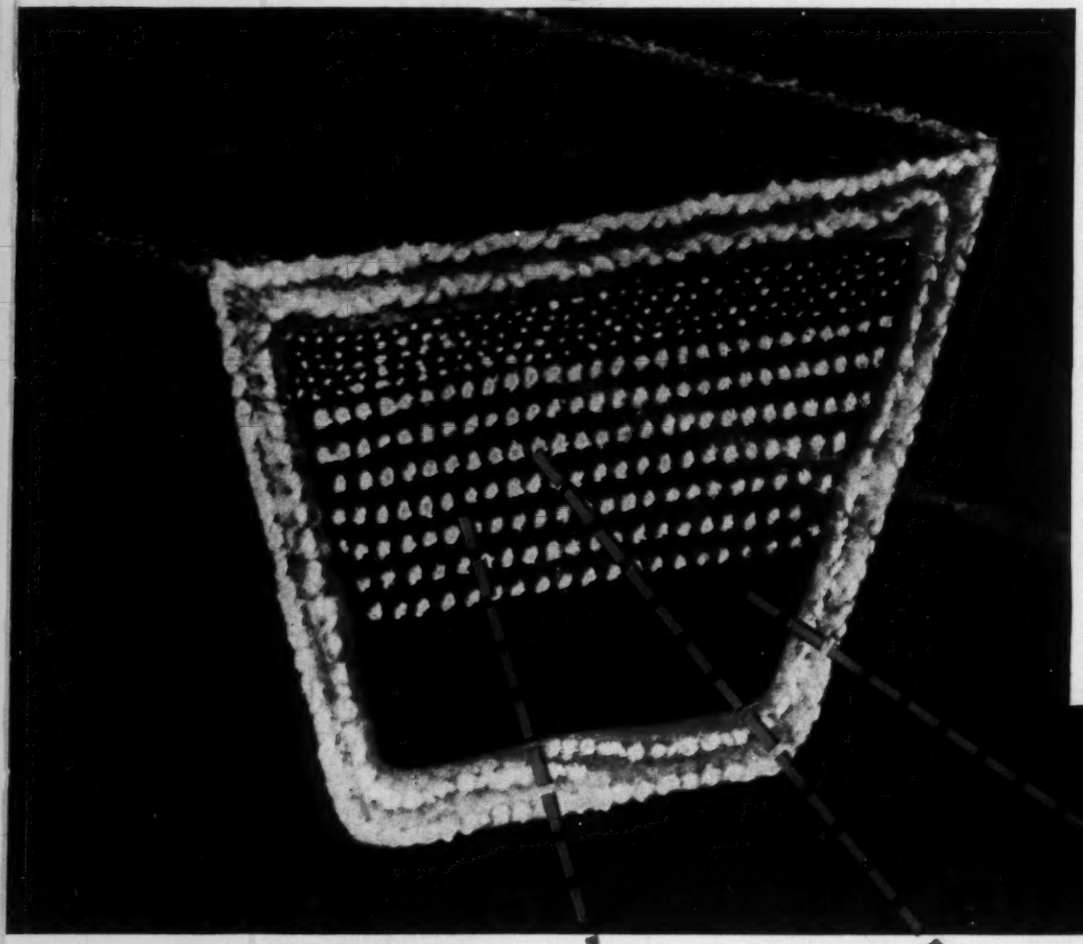

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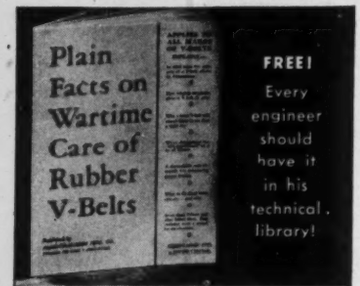

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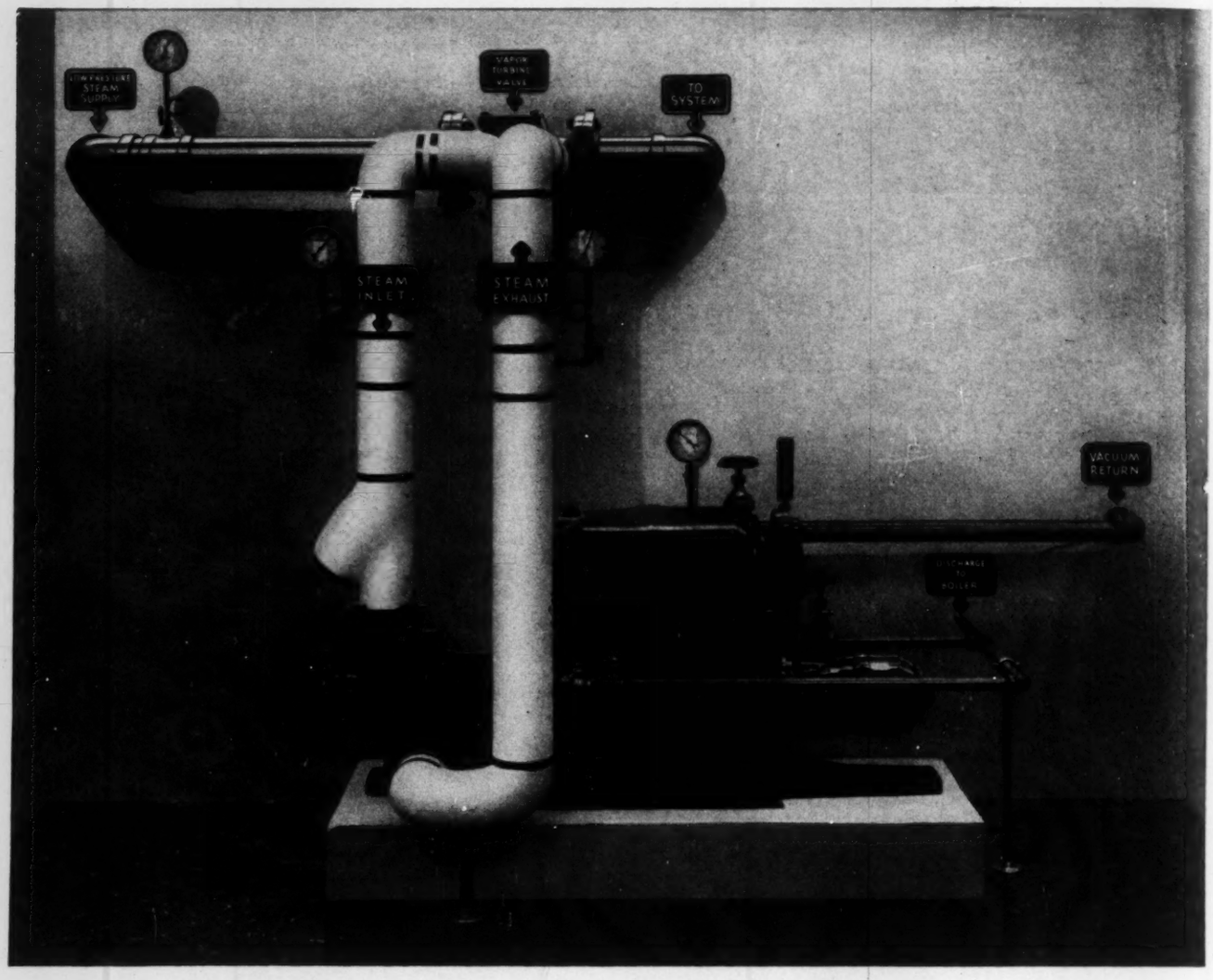
Interrupted Electric Service will not stop this NASH Heating Pump!



In Hospitals, Greenhouses, Schools, Public Buildings, Theatres, wherever heating systems must not fail, install the Nash Vapor Turbine, for it is independent of electric current failure, and continues to operate as long as there is steam in the system.

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How Ducts Are Made of Substitute for Sheet Metal

T. M. Cunningham Describes Use of Sheet Board Materials for Ventilating and Air Conditioning Ductwork Construction

SUMMARY—Conservation involves substitution, salvage, simplification, and specification. It is with the first of these that we are concerned here—the use of non-metallic sheet board for ducts, in place of sheet metal. One duct system estimated to require 300,000 lb of sheet metal needed but 66,000 lb, sheet board being used as a substitute. . . . Use of a new material makes necessary new techniques and fabricating methods. Mr. Cunningham, who is construction manager of Carrier Corp., gives practical, how-to-do-it information here on the factors to consider in choosing a board, thicknesses, duct design, use of sheet metal slip joints, fabrication of fittings, supporting ducts, and how to make access doors.

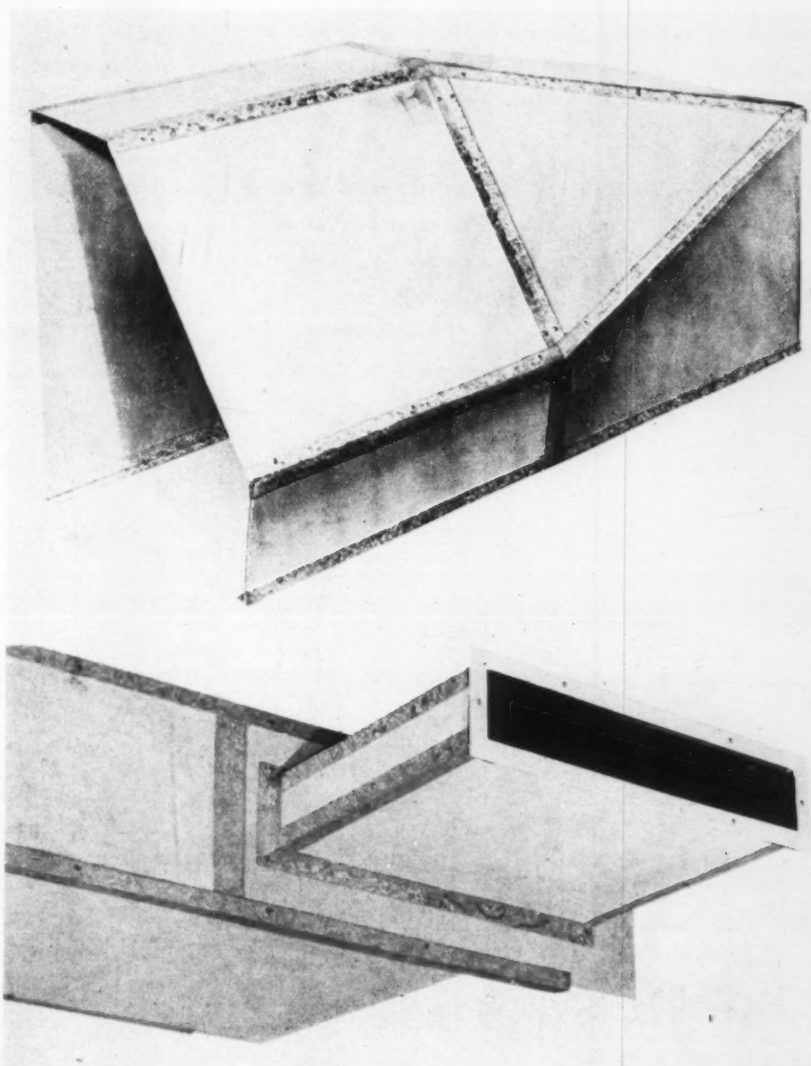
SHEET METAL, long used for ducts and casings by the ventilation and air conditioning industry, is being replaced with sheet board, as a substitute for critical materials. Through the cooperation of contracting engineers, manufacturers, air conditioning engineers, sheet metal craftsmen, and architects, modern air distributing systems are now being made of sheet board. The new sheet boards do not entirely replace sheet steel, but so great are the applications that one duct system estimated at 300,000 lb required but 66,000 lb of sheet metal; sheet boards are substituted for the remaining 234,000 lb. Duct sizes on the installation vary from 72 x 54 in. to 10 x 9 in., indicating the wide range of dimensions that sheet board ducts may have.

In selecting a sheet metal substitute, several factors must be considered, such as availability of substitutes, ease of fabrication, strength and durability of finished duct or casing, rigidity of material, and surface resistance to air flow. In some respects the available substitutes have advantages over sheet metal; because of their rigidity they do not require the breaking used with metal ducts, and they have an inherent insulating value, as well as good sound deadening properties.

In addition to the factors mentioned above, the substitute for sheet metal should meet the following specifications: It must have a hard smooth finish, and be non-hygroscopic, non-warping, and non-inflammable. Preferably the material should be workable with tools usually used for sheet metal so that construction of sheet board ducts does not involve a retooling program.

Thicknesses

Sheet boards are available in several thicknesses; 1/8 in. minimum is suitable for small duct work and 1/4 in. thickness for large ducts. From experience in using the metal substitutes it is believed that 3/16 in. thick sheet board may be used throughout for air distributing sys-



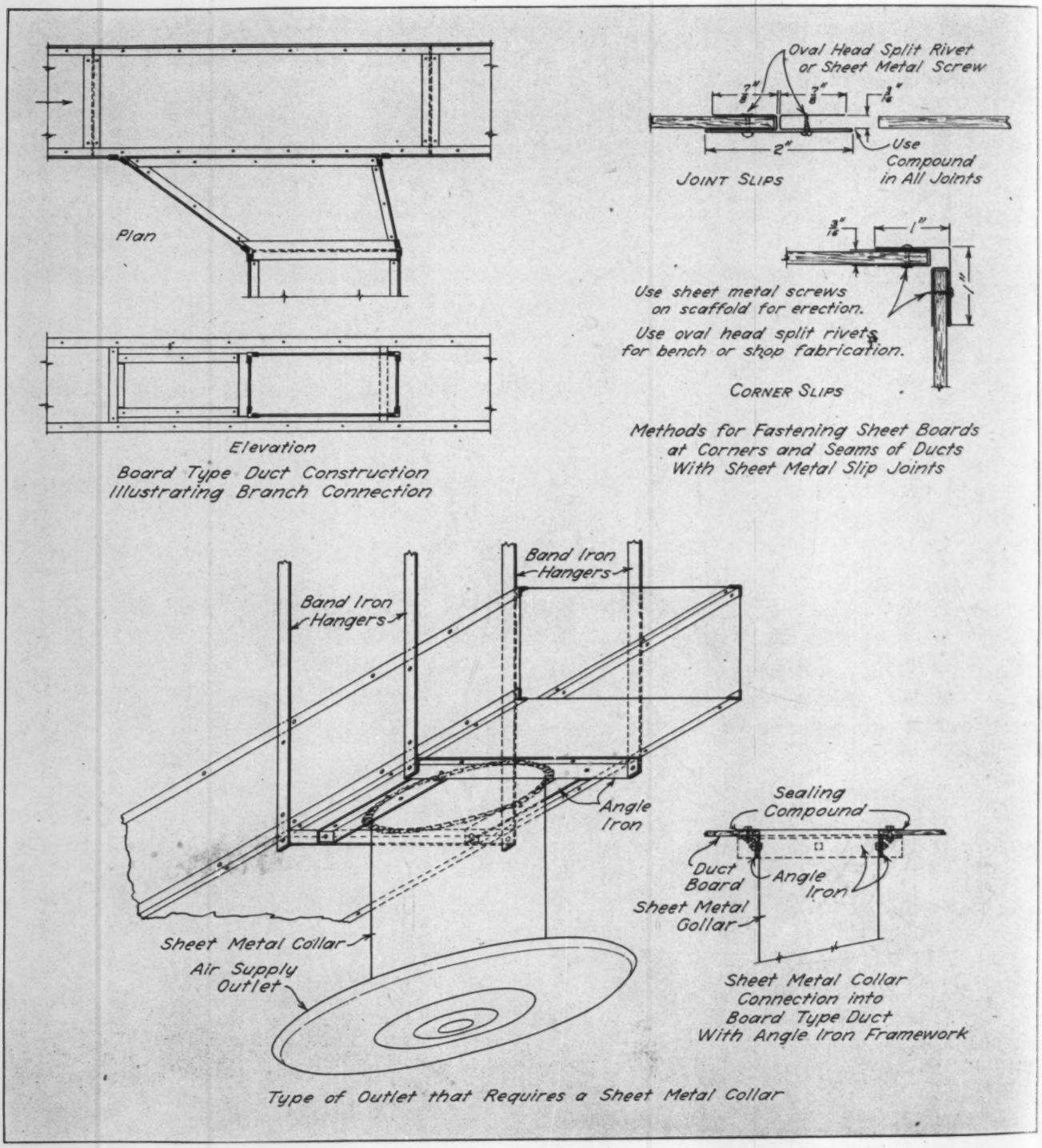
Top—**This offset construction shows adaptability of sheet board to conventional duct design. . . . *Bottom*—In many duct layouts, the sheet board outlet collar is used effectively**

tems ranging in capacity from 10,000 to 50,000 cfm. By using only one thickness for an entire duct system, fabrication costs are reduced and tooling problems are simplified, resulting in lower installation costs. In systems larger than 50,000 cfm it is advisable to use ¼ in. board to eliminate stiffening and other construction extras.

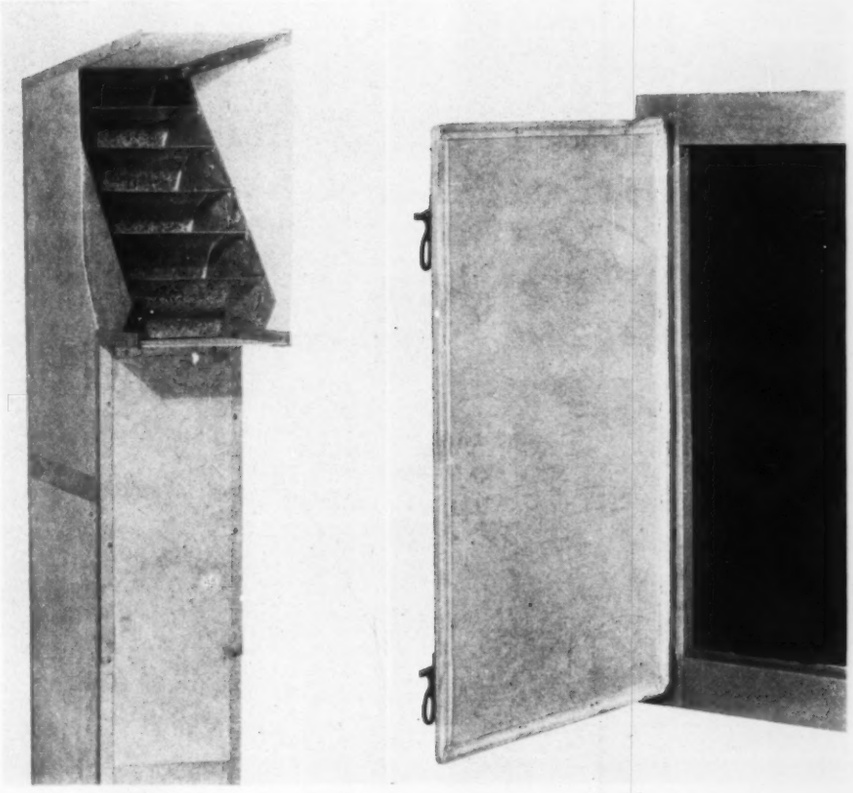
Duct Design

The design of ducts made by sheet board is not very different from those made of metal. The surfaces of the substitutes usually are about as smooth as sheet metal. Therefore, the resistance to air flow of the sheet board duct is practically the same, and it is unnecessary to increase duct size.

The installation of the board should be made with the smooth surface of the board on the inside in contact with the moving air. Most boards have a smooth and rough surface developed in the process of manufacture; for some types there is little difference in the two surfaces, but this can be observed and the smooth side turned in. Although the surface characteristic is somewhat different from galvanized sheet metal it seems to be as smooth. The cross slips, corner slips, sheet metal screws, and rivets have a slight effect on increasing the friction, but there is very little difference in the overall resistance to flow. The


Plan
Elevation
Board Type Duct Construction Illustrating Branch Connection
Oval Head Split Rivet or Sheet Metal Screw
7/8"
7/8"
1/4"
2"
Use Compound in All Joints
JOINT SLIPS
3/16"
1"
2"
Use sheet metal screws on scaffold for erection.
Use oval head split rivets for bench or shop fabrication.
CORNER SLIPS
Methods for Fastening Sheet Boards at Corners and Seams of Ducts With Sheet Metal Slip Joints
Band Iron Hangers
Band Iron Hangers
Angle Iron
Sheet Metal Collar
Air Supply Outlet
Sealing Compound
Duct Board
Angle Iron
Sheet Metal Collar
Sheet Metal Collar Connection into Board Type Duct With Angle Iron Framework
Type of Outlet that Requires a Sheet Metal Collar

Left—**Square vaned elbow showing duct work made of sheet board and vanes made of sheet metal. . . . *Right*—Access door of sheet board opened to show gasket held in place with split rivets**



ASHVE Guide chart for friction losses can be used with assurance of satisfactory results, and the installations made so far for medium and large size duct work have proved this method.

For ducts 12 in. x 12 in. and smaller, it is recommended that a *C* factor of 45 be used in lieu of the sheet metal standard of 50; therefore, friction losses taken from the chart should be increased in the ratio of 50/45 for small ducts.

As square vaned elbows and other fittings may be made in sheet board ducts, the layout of the air conditioning system does not differ from that which has long been the practice in the air conditioning industry. Illustrative of this fact is the sheet board elbow using metal vanes shown in one of the illustrations.

Materials

Materials used in sheet board ducts consist of sheet board, sheet metal slip joints, and parts such as hangers for which there has not yet been found a suitable substitute.

The sheet boards make up the walls, tops, and bottoms of ducts and many offsets, reducers, transition fittings, dampers, deflectors, splitters, and some vanes. The sizes of sheet boards permit selection of duct dimensions that keep waste at a minimum. The large size board is approximately 42 x 96 in. Dimensions of smaller boards depend upon the kind of board selected, as they vary with different manufacturers.

Sheet metal slip joints may be used to hold the sheet boards in place. Using a compound or cement to seal the joints, this type of construction provides a rugged system, assures tightness of seams and joints, and is not difficult to build. The sheet metal slip joints are factory fabricated products, available in quantities at low cost. Usually made in 8 ft lengths, the joints are cut to fit the job with waste kept at a minimum.

In addition to making seams and joints, the sheet metal slip joints may be used in the construction of offsets, reducers, and transition fittings by breaking the slips at the proper angle. In some cases the standard slip joints may be used for outlet collars and branch connections. However, sheet metal collars are required for some outlets, as shown in one of the sketches.

Fabrication

In building an air conditioning system with sheet board, it has been found that some fabrication may be done entirely at the bench—especially is this true of small duct sizes. Larger ones may be partially fabricated on the bench with complete assembly being done on the scaffold as an erection function. On ducts that are bench fabricated, split rivets or tubular rivets may be used to hold the sheet boards in the metal slip joints.

When partial bench fabrication and scaffold completion is used, sheet metal screws are advised so that there will be no need for a mechanic to crawl inside the duct to fasten the joints in place. Parts such as dampers and deflectors are constructed of sheet board by using the same method as when sheet metal is used.

Hangers

Support for the sheet board duct may be the same as that used for a sheet metal duct, with one exception. Conventional band iron or rod trapeze type hangers are used with the same spacing that has long been the practice in such work. The exception is that the supports are heavier, because sheet board ducts are usually of greater weight than metal ducts.

Access Doors

Access doors in apparatus casings should be made of heavy board to assure both rigidity and strength. Thickness of the board recommended varies from ¼ to ⅜ in., depending upon the size of the door. One of the photographs shows a 20 x 40 in. access door made of ⅜ in. board, including the gasket that prevents leakage around the door. Attached by means of split rivets, the gasket is placed about ¾ in. from the edge for a tight fit.

THE DRYING OF FOODS

War Creates Tremendous Demand for Dried Foods to Save Shipping and Storage Space, Prevent Spoilage . . . . . W. R. Marshall, Jr., Describes the Various Problems Involved

SUMMARY — The importance of food drying has predominated in times of war, present practice in the field having received its development and expansion during the Boer War and World War I. The great need for large supplies of concentrated foods for our armies and those of our allies — and our civilian allies — has created a tremendous demand for dried foods. . . . There is a big field for more engineering attention to food drying problems, and heating, air conditioning, and piping are all involved. For this reason, HEATING, PIPING & AIR CONDITIONING presents in a group of articles —of which this is the second—a comprehensive and practical review of food drying today. A description of the general problem of food drying was given in Mr. Marshall's first article, published in the September HPAC. . . . The author has specialized in the subject of drying, and is connected with the technical division of the engineering department at E. I. du Pont de Nemours & Co.

IN A MAJORITY of food drying processes, the medium for transferring heat to the wet food is steam heated air or hot gases, and drying is accomplished by circulating the hot air or gases over the surface of the food. From the standpoint of external drying conditions this is a simple procedure. However, the actual process of moisture flow within the material, and the factors governing the rate of its movement, constitute an extremely complex problem when approached from an analytical or theoretical basis.

The solution of any drying problem is the type of dryer selected to do the job, and the great variety of drying equipment indicates the diversity of drying problems. The following paragraphs present a brief survey of various drying methods and types of dryers. Some of these have already found applications in food drying, while others are either just finding their place or have not yet been utilized in this rapidly increasing field of industrial drying.

Methods and Equipment

The primary purpose of a dryer is the transmission of heat to evaporate water from the material to be dried, and the differences among dryers are usually differences among the methods employed to contact the wet material with the heating medium.

The type and size of the dryer which will be used for a given food drying operation will depend primarily upon the desired final form and moisture content of the product, the physical characteristics of the wet feed, the production capacity desired, the permissible drying temperatures, and the manner in which heat may be applied to the material.

Classification of Dryers—Several methods can be used to classify drying equipment, none of which, however, is completely satisfactory. In general, dryers may be divided into two general groups; namely, dryers in which the material comes into direct contact with hot gases; and dryers in which the heating occurs indirectly through heated surfaces. All dryers in which drying is accomplished by means of heated air or gases circulating over the food may be placed in the first group. In the second group will be found those dryers in which a retaining wall separates the food from the heating medium so that heat transfer occurs by means of the contact between a hot solid surface and the food to be dried. Examples of the latter are drum dryers, vacuum dryers, and indirect rotary dryers.

Dryers may also be classified on the basis of the physical characteristics of the material to be dried (8, 14).* This procedure is also reasonable, since the nature of the material is an independent variable of which the dryer is a function. With regard to the method of operating dryers, three classifications are possible: Batch operation; semi-continuous operation; and continuous operation.

Types of Dryers Suitable for Foods—It would be possible to consume many pages in a discussion of the kinds of dryers suitable for food drying. However, since this was not intended to be a treatise on drying equipment, it was believed that the best method for outlining the salient features of dryers would be a table or chart, and thus the accompanying table was prepared. It outlines important characteristics of dryers suitable for foods, and it is based, in part, on the three methods of classifying dryers as noted above. The first column gives the name generally applied to the type of dryer described, and the second column indicates the class of the dryer with respect to its operation. The third column compares the various methods of conveying the material during drying. The fourth column classifies the dryer with respect to the material which it is designed to handle. The method of transferring heat to the food is indicated in the fifth column. The range of capacity of each dryer, expressed as pounds of commercial dry food per hour, is given in the sixth column, while the last column compares the range of energy consumption to be expected among the various kinds of dryers. The numbers in parentheses in the first column refer to references at the end of this article which give more detailed information about the particular drying method and type of dryer listed. Drawings of each type of dryer would be desirable; however, since representative line drawings have appeared several times in the literature (39, 49), it was felt unnecessary to repeat them.

*Numbers in parentheses refer to references at the end of this article.

SUMMARY OF THE VARIOUS TYPES OF DRYERS SUITABLE FOR DRYING FOODS

TYPE OF DRYER AND REFERENCE NUMBERS (See references at end of article)	OPERATION	METHOD OF SUPPORTING AND TRANSPORTING MATERIAL	TYPE OF MATERIAL HANDLED	METHOD OF TRANSFERRING HEAT TO THE WET FOOD	USUAL CAPACITY RANGE, LB COMMERCIAL DRY FOOD PER HR	USUAL RANGE OF ENERGY CONSUMPTION, ENERGY PER LB OF WATER EVAPORATED
Tray and compartment dryers (12,13,28,30,41,44,48,50)	Batch	Food placed on trays and moved manually in and out of the dryer.	Almost any kind that can be placed in a tray.	Steam heated air passing over the trays and surface of the food.	Up to 1000	3.0-5.0 lb steam/lb water
Continuous tray and tunnel dryers (6,23,37,44)	Continuous and semi-continuous	Food carried on continuous belt, or loaded on trays which are put on trucks which in turn are intermittently advanced through a tunnel.	Practically any kind except liquids.	Steam heated air or hot flue gases passing over the surface of the material on the belt or in the trays.	Up to 4000	2.5-4.0 lb steam/lb water
Conveying screen or through-circulation dryers (32,32a)	Continuous or batch	Food carried on a screen or perforated metal conveyor. Feed and discharge are automatic. In batch dryer food is held on screen bottom trays. Air blows down through 4 to 6 trays.	Granular materials; also subdivided foods which will form a permeable layer on the screen so that hot air may be blown through it.	Usually steam heated air. May also be gas or oil heat. Hot air or gases pass down through the bed of material on the screen.	200-4000	1.5-2.5 lb steam/lb water
Rotary dryers, a. Direct b. Indirect c. Steam-tube d. Roto-louver (4,10,16,24,36,43,46)	Continuous	Food automatically charged to the dryer. Material is transported through the drying zone by means of the rotating shell which has a slight pitch.	Granular and free-flowing solid foods which will not adhere to the rotating shell.	a. In the direct rotary the material comes into direct contact with hot air or hot flue gases which may flow counter-current to or co-current with the solid stream. b. Heat is transferred through the dryer walls in the indirect. c. In the steam-tube rotary the heat is transferred through steam heated tubes lining the dryer shell. d. In the roto-louver, hot gases pass through a bed of the material.	300-50000	a.) b.) 1500-5000 Btu/lb water c. 1.7-2.5 lb steam/lb water d. 1.75-3.0 lb steam/lb water
Spray dryers (5,11,18,19,29,33,34,40,42,47)	Batch or continuous	Material as a liquid or a slurry is sprayed into a drying chamber by means of centrifugal atomizer, pressure type nozzle, or atomizing nozzle. The particles settle by gravity to bottom of chamber or are recovered in dust collectors.	Liquids, slurries, and suspensions.	Hot air or flue gases in direct contact with the dispersed drops.	200-4000	2.0-4.0 lb steam/lb water
Pneumatic conveying dryers (2,35,38)	Batch or continuous	Material in a granular form is conveyed and dried in a stream of hot air or gases.	Fine, comminuted foods whose mesh size is not greater than about 2 mesh.	Hot air or flue gases in contact with the entrained particles.	200-1000	1.5-3.0 lb steam/lb water
Drum dryers, Atmospheric Vacuum (21,45)	Continuous	Material in a liquid or slurry form is carried and dried on a steam heated metal drum.	Liquids, slurries and suspensions.	Heated metal surface in contact with a thin film of the wet material.	Up to 1000	1.5-2.5 lb steam/lb water
Agitator dryers—Vacuum and atmospheric pan, Vacuum rotary (1,9,25)	Batch	Material is charged and discharged manually.	Granular materials, liquids, slurries, and pastes.	Steam heated metal surfaces.	Up to 1000	2.0-3.0 lb steam/lb water
Vacuum tray dryers (7,15,17)	Batch	Material is charged and discharged manually.	Any materials suitable for trays and which are temperature sensitive.	Steam heated surfaces.	Up to 500	1.5-2.5 lb steam/lb water
Pulsation type dryer (26,27,28)	Batch	Material held on trays as in the case of tray dryers.	Materials which form a porous mass.	Steam heated, pulsating air which is alternately forced in and sucked out of the porous layer on the tray. Pulsations may be from 30 to 100 per min.	Up to 1000	2.0-4.0 lb steam/lb water

A brief discussion of the contents of the table is in order. In general, the majority of food dryers for the past 20 years have been either of the tray and compartment, or continuous tray and tunnel, types, except for a few notable exceptions such as spray dryers and drum dryers which are used for drying liquids and slurries. In general, however, solid foods have nearly always been dried in tray and tunnel type dryers. With the development of large scale production of dried foods, it has been found desirable to introduce the continuous dryers, such as the conveying screen or through-circulation dryer, and the rotary dryer. Probably the outstanding advantages which continuous dryers offer at the present time are: Practically no labor requirements, except for periodic supervision; lower energy consumption per pound of water evaporated; and continuous operation. To offset these advantages, the tray, truck, and tunnel dryers offer, in addition to low maintenance charge, a comparatively small initial cost compared with the continuous dryers, although the yearly labor charges might very soon nullify this important advantage.

Let us briefly consider now each type of dryer as listed in the table.

Tray and Compartment Type Dryers—In these dryers the food may be loaded 3 to 4 in. deep on trays whose average area may be 4 to 6 sq ft. It is important to maintain uniform loading on the trays. The trays may be placed directly into the dryer or they may be placed on trucks which are then run into the dryer. Steam heated air is circulated *across* the trays. The air is generally reheated and recirculated with a certain portion being exhausted at a predetermined humidity. One of the chief difficulties in this type of dryer is to obtain uniform air flow over all the trays.

It is possible by means of control

instruments to regulate the air temperature in these dryers to correspond to any desired time cycle of temperatures. Dryers of the tray and compartment type have a low first cost, they are easy to install, and they have low maintenance charges.

Continuous Tray and Tunnel Dryers—In the continuous tray dryer, the food is carried on a moving belt across which the drying air is blown. It is not unusual to have three or more continuous belts placed vertically above one another, the material falling progressively to the one below it. Such an arrangement permits the handling of large capacities. In the tunnel type, trucks loaded with trays are periodically moved through a tunnel in which the drying air is circulated. Various directions of air flow are possible. Thus, the air may flow parallel to the food movement, countercurrent to it, it may enter in the middle and flow in opposite directions toward each end, or it may even spiral through the tunnel. Drying times are generally long in this type of dryer. Unless reheating coils are used in these dryers, the air conditions will be fixed at each point in the dryer, thereby reducing the flexibility of operation.

The tunnel dryer is capable of handling large amounts of food with great economy of space and operation, and is especially applicable to the drying of fruits.

Conveying Screen or Through-Circulation Dryers—The characteristics and drying theory of this type of dryer have been described by Marshall and Hougen (32). Its application to food drying represents one of the most recent developments. The particular characteristics of this dryer are as follows:

A feeding device which may be combined with a subdividing preforming machine, such as a ricer for potatoes, or a slicer or cuber.

A conveying screen which carries the food continuously through the dryer.

Fans which circulate steam heated air *through* the bed of material on the screen. The air is generally blown upward in the first units, and downward thereafter.

Individual steam coils for each unit, whereby the air temperature may be controlled throughout the drying process.

A kicker which agitates the material to provide fresh surfaces for drying midway in the operation.

A reloading device, whereby the food is reloaded from a depth of 2 to 3 in. to a depth of as great as 18 in. in some cases for the last stages of drying, thereby increasing the capacity of the dryer.

Automatic temperature controllers.

The batch through-circulation dryers are low capacity dryers. They resemble the tray dryers, except that in their operation the drying air blows down *through* the material on screen bottom trays.

Rotary Dryers—These dryers are widely used in industrial drying operations. Primarily, they are high capacity dryers. They are characterized by a rotating shell, slightly inclined, which moves the material through a stream of hot air or gases. Flights attached to the inside of the shell cause the material to cascade and thereby to receive more intimate contact with the drying medium. One disadvantage of the rotary dryer's cascading action is the breaking and dusting of the material. This has been eliminated to some extent in the roto-louver dryer (4, 16) whose action depends upon the passage of air through the bed of material which is continuously rolling over the louvers out of which the air flows. This resembles through-circulation drying. In the usual type of rotary dryer, the nature of the air flow in the dryer fixes the drying conditions at every point, so that there is little flexibility of operation in this type of dryer.

Spray Dryers—Spray dryers occupy a very specialized field in drying, since they are designed to handle only liquids or slurries. Drying times in spray dryers are of the order of 20 to 30 sec. Because of the cooling effect produced by rapid evaporation on the surface of the drops, heat sensitive materials are often conveniently dried in spray dryers. The final form of the product is a dry powder. It is important to realize that spray drying is becoming more and more widely used in industrial work, and the possibility of its use should constantly be borne in mind. In food drying, it is now used chiefly for drying milk and eggs. However, it is quite conceivable that it could be used for other foods which can be put into a form suitable for spraying; e.g., purees and soups.

Pneumatic Conveying Dryers—This type of dryer has, as yet, found no application to food drying, insofar as the author is aware. Certain characteristics of food drying may prevent wide use of the pneumatic conveying dryers (e.g., the wide range between the initial and final moisture contents). These dryers operate best when they must dry from a relatively high to only a moderately low moisture content. In other words, their operation does not facilitate drying from high to low moisture contents. These dryers operate best when only surface moisture must be removed. If more drastic drying is required, two or more stages are used.

In order to use this dryer for food drying, it is necessary that the food be rather finely divided. Ground food which is fed to this type of dryer would be carried along by a rapidly moving stream of hot air or gases. The air velocity may range from 75 to 150 fps, which means that drying occurs very rapidly. Rapid evaporation tends to keep the particles relatively cool; i.e., approximately at the wet bulb temperature of the drying air. It is sometimes practical to operate pneumatic conveying dryers in multiple stages. The particle size of the material to be dried should not exceed about 2 mesh, and good practice requires that the solid to air ratio (lb solid per lb air) should lie between 0.1 and 1.0. If it is lower than 0.1, uneconomical operation is liable to result. The dry product is generally collected in cyclones or in bag collectors.

Drum Dryers—Food drying by means of drum dryers has been developed extensively by one company in this country. In drying on drum dryers, the food in the form of a slurry heated to 180 F is fed to a strainer. The strained pulp is then spread on the surface of a steam heated drum which rotates and carries the thin film around for about three-quarters of a revolution. During rotation, water is evaporated leaving a layer of dried food (usually either fruit or vegetable) which is continuously scraped off by a knife. The drying time on 5 to 10 ft drums may be of the order of 20 to 30 sec. The dried product, having the appearance of a crepe-like film, is discharged into an air conditioned room from which it is conveyed for packaging.

Agitator Dryers—Dryers of this type are of the class in which heat

is transferred through retaining walls. The material is agitated in a steam jacketed pan or horizontal cylinder by means of scraper arms or blades. Pan dryers may be of the atmospheric or vacuum type. These dryers, however, have not yet been widely used for food drying. One of their chief disadvantages is the attrition action of the agitators. Another is that they are batch operated, which requires a certain amount of labor, and under present war conditions the problem of meeting the demand for adequate labor may be exceedingly difficult to solve.

Vacuum Tray Dryers—These are quite similar to tray and compartment type dryers, except that drying is performed under vacuum. These dryers would be used when a material is temperature sensitive, since vacuum drying greatly reduces the temperature at which evaporation occurs. The chief disadvantage of this type of dryer is the cost and upkeep of the vacuum producing equipment. It is not suitable for high capacities.

Pulsation Type Dryer—The so-called "pulsation" type dryer (26, 27, 28) was developed in Europe and as yet has received little attention in this country. Its operation represents a relatively new principle in drying. In essence, the operation of the pulsation dryer comprises an alternate blowing and sucking of air in and out of the wet material as it lies on a tray; the cycle of alternate pressure and suction may be repeated from 30 to 100 times per min. This method is claimed to have the advantage of drying evenly throughout the mass of material, and of increasing by one-third the drying rate over the usual tray drying method. The author is aware of no application of this method to food drying in this country.

Two relatively new drying methods were not included in the accompanying table, but are worthy of mention. These methods are drying by infrared radiation and drying by means of high frequency induction. The use of radiant heat in food drying has been reported in one instance (3), but no application of high frequency currents to food drying has yet been described. Infrared drying has found many applications in other drying processes, while induction drying has been used chiefly in experimental drying of wood. The unique feature about the use of high frequency for drying purposes is that the material being dried has a tendency to become heated in its interior more rapidly than it does on its surface, a situation which is the reverse of other methods.

For further information concerning dryers and their characteristics, the following references should be consulted: (8, 14, 22, 39, 48, 49).

Dryer Performance

It is important to note that for economical operation, steam consumption of a food dryer should not exceed about 4.0 lb of steam per lb of water evaporated. In terms of other methods of heating this may be about 4000 Btu per lb of water evaporated. It is generally quite possible to operate below this figure in well designed and properly operated dryers. Continuous dryers should remain within the range of 2 to 3 lb of steam per lb water evaporated. It is important to note in this connection that the energy consumption of a dryer will be lowest when drying is carried only to those moisture contents which still permit ready movement of moisture to the surface of the material being dried. When drying is carried to low moisture contents where the evaporation rate is low, then a high energy consumption per lb of water evaporated must be expected, since the heat being supplied is not being used entirely for evaporation. In food drying, there is the problem of going from very high initial moisture contents to a moisture content where drying proceeds quite slowly. For this reason, the energy consumption cannot be expected to be as low for drying foods as it is for other more easily dried materials.

The usual methods of reducing the energy consumption of a dryer include recirculation of as much air as is compatible with the operation; i.e., exhaust spent air at the highest practical humidity; reducing heat losses through the dryer walls to a minimum; maintaining a uniform air flow over or through the material to insure uniform drying and to keep the drying time to a minimum; and not drying the material to a moisture content which is lower than necessary.

The problem of reducing the fuel consumption in any process is a major one during the present crisis, and drying operations are receiving a great deal of attention as a potential source of fuel savings.

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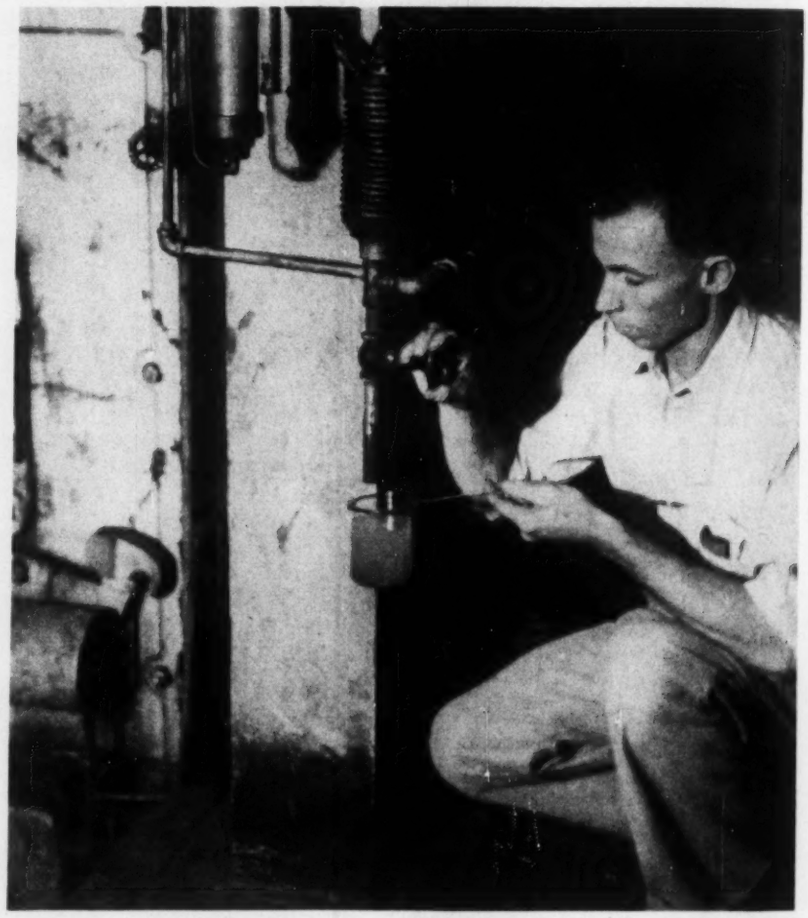
Don't Trust Your Memory on Maintenance Work

Care of Equipment So Vital in Wartime That Regular System for Routine Maintenance Is Necessary....By L. O. Adams

SUMMARY—Never has the need for careful maintenance of buildings and their equipment been so great, for due to wartime restrictions and scarcities, "the things we now own are the most valuable we have ever owned". Routine maintenance operations shouldn't be trusted to memory. Mr. Adams, who is director of buildings and grounds at the University of Louisville, suggests "tying a string to your finger" in the form of a card file, each card listing a piece of equipment and marked with the date on which that equipment should be given attention. . . . He includes pointers on taking care of heating equipment, and stresses the added importance of fire prevention



Taking a sample of boiler water for a routine test

NEVER HAS the need for careful maintenance of buildings and their equipment been so great. Neglect in peacetime means higher than necessary costs for repairs, and possibly the greater expense of replacements; in wartime, with repair parts and replacement equipment difficult to obtain, there must be more than usual diligence in taking care of things if vital services are to be continued.

Proper care and maintenance of buildings and equipment will become increasingly difficult in the critical months ahead. Competent manpower and certain materials have already become very much of a problem and these difficulties will inevitably grow as the military forces of the country are expanded. It can be expected that there will be less of the services of the type which occupants of buildings have rightly come to expect. Some services may have to be dispensed with. Present difficulties offer an excuse for providing even poorer service, and this tendency must be guarded against. To permit a decline in the standards of care of property would not only be detrimental to the country's best interest to the extent to which an institution is engaged in the war effort, but would also present, for the future, the problem of restoring these standards, which in so many cases have been painfully and laboriously established.

It is now more than ever important that routine maintenance should not be left to memory. Vital equipment needs to be taken care of on definitely established schedules; even a simple card system will be of great help in accomplishing this. Each piece of equipment should be listed on a separate card, and these cards marked for attention on prearranged dates. Each day's maintenance jobs should be issued by the person in charge of the system to the responsible foreman or workman. The master cards are held for follow up, in case the job order is not returned as completed within a reasonable time. This is not a new idea. It is surprising, however, the number of plants which have no established routine for maintenance. It is now of vital importance to our whole economy that scheduled maintenance replace hit-or-miss methods, even in the small plant.

This summer, new problems have

been presented to those colleges and universities operating on the accelerated program. Where under ordinary conditions the summers have been devoted to major maintenance work, this past summer has seen a tendency to set aside some of this work to take care of the pressing problems which arise in connection with each day's operations. Careful thinking is required to sift out all unnecessary work, in order that the care of things vital to the operation of the plant will not be overlooked.

Unit ventilators and **unit heaters** have in many cases been used as fans, which has increased their need for maintenance. Filters were likely removed and stored; these should have been gotten out before the heating season, and cleaned and reinstalled in the units. Connections to run tap water through such units may have been surreptitiously made by individuals who do not realize that any extra cooling effect so achieved is usually so small as to be negligible. The results, however, may be disastrous if water is allowed to get into the heating system and start corrosion of traps and other parts.

In the southern states, **spray systems** on metal roofs may have been used to reduce inside temperatures. This may have hastened deterioration of the roof coating, and inspections are needed to find whether repairs are necessary before the bad weather sets in.

Steam traps should be tested annually. A simple rig can be made by which each trap can be tested for passage of water and closing off against steam. Such a program results in higher vacuum, better circulation, more comfortable conditions in the buildings, and lower heating costs.

Boilers need to be taken off the lines periodically for cleaning and maintenance. See that the baffles are examined, and any breaks repaired. High stack temperature, with a resulting lowering of efficiency, is the result of failure to make such repairs when needed. Corrosion eats away steel. If insurance is carried, as it should be, the beginnings of corrosion ought to be discovered on the annual inspection. However, the foreman responsible for the heating plant should actually go into the boilers with the inspector to see that a thorough inspection is made.

Boiler water should be tested regularly in order that tubes may be kept free of scale and tube burnouts avoided.

Air leaks in **boiler settings** result in higher heating costs. The fireman can check the setting with a candle while the boiler is in operation, marking all points of infiltration of air. These should be sealed and if necessary, the entire setting coated with boiler seal.

The importance of boiler room **instruments** in reducing fuel consumption cannot be overlooked, and takes on a broader significance when related to the national need for conservation of transportation facilities. At a minimum, a central heating plant should have a recorder for CO_2 and flue gas temperature; a steam flow integrator and recorder; an indicator of draft under the fire, over the fire, and in the last pass; and recorders to show feedwater temperature, temperature of the returns from the condensate system, and boiler pressure.

When the functions of these instruments are explained to firemen and results are demonstrated, there is usually wholehearted cooperation in their use. In order that these instruments may do their job properly and continuously, they should be maintained regularly by a competent mechanic. The unmistakable results of failure to care for and use such equipment properly are much higher costs for heating, and added maintenance because of the extra wear on plant equipment.

Stokers require a thorough going-over once a year. Those in the central heating plant are not usually overlooked; the smaller ones, however, handled by a janitor-fireman, are sometimes neglected until trouble develops. These should be on the routine maintenance sys-

Testing steam traps for proper operation. The rig includes a radiator for condensing steam, water gage, and steam pressure gage. Connection at bottom of radiator is for test to see whether trap passes water as it should; if it holds back water, the water shows up in gage glass. Connection at top of radiator is to see if trap passes steam

Checking a boiler setting for air infiltration, with a candle in one hand to show air flow and a trowel with boiler seal in the other to repair leaks

tem so that proper care of them is assured.

In order that **temperature control** systems in buildings may give the service for which they were designed, all dampers should be checked for freedom of operation. Since in a single building, there may be a quantity of these, each should be listed so that an individual check is guaranteed. In many cases, the operation of these important systems is left entirely to the custodian of the building, with the result that faulty operation of some parts vital to proper comfort conditions may continue for a long time before discovery. Only by an established maintenance procedure, rigidly carried out, can this be avoided. It is well to blow out thermostats with a stream of air of sufficient force to dislodge all dust particles and to leave the mechanism clean and free to operate.

Vacuum cleaning of buildings, rather than sweeping, removes the dust instead of re-depositing a part of it in other places in the room, in the thermostats, and in ventilating equipment. If such equipment is available, the advantages of its use in saving labor, insuring cleaner and more healthful conditions, and in reducing maintenance of equipment, should be impressed on the custodial force. The objections to the use of vacuum cleaning by building custodians can be overcome if they can but be made to see the improvements which follow its use.

Fire Hazards

The possibility of fires from incendiary bombs has increased the receptiveness of individuals to instructions in fire prevention. With present restrictions on building materials, a fire may cause an irreplaceable loss and closing down of some important activity. Local fire prevention bureaus in many localities have films showing proper use of fire extinguishing equipment in buildings, and the proper method for handling incendiary bombs; they are glad to make showings before groups of building occupants and employees.

One of the foremost rules for watchmen is that they shall guard against fire, and shall attempt to extinguish it while it is still smoldering and before it gains headway.

Watchmen should be periodically cautioned to inspect the buildings on the first round so that oily waste, rags, or any refuse in which a fire might start may be disposed of. The first round after coming on duty should include a check to be sure all fire extinguishers are in place, and that the approaches to them are clear.

Fire extinguishers should be examined annually and the soda and acid type recharged. Standpipe hose must be kept dry to prevent mildew.

Instruction of personnel in the use of fire fighting equipment in the buildings is desirable. A good time to do this is on the annual recharge of the soda and acid type. Practice can be obtained by discharging the extinguishers; this also provides a check to see that the hoses are open and without obstruction.

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HEATING AND AIR CONDITIONING INDUSTRIES HELP IN SCRAP DRIVE

CLOUD WAMPLER, president of the Carrier Corp., and Herbert V. Kohler, president of the Kohler Co., are participating in the work of the American Industries Salvage Committee to enlist the full cooperation of individual industrial concerns in the scrap salvage program of the War Production Board, according to an announcement by Robert W. Wolcott, chairman of the committee. Mr. Wampler is serving as liaison between the American Industries Salvage Committee and individual companies in the air conditioning industry, while Mr. Kohler performs the same function for the heating and plumbing industries.

Mr. Wampler has written to companies in the industry urging full and complete cooperation with the program of the industrial salvage section of the WPB. He has also asked that each company appoint a responsible official to assist in any way possible the local general salvage committees that have been established by the WPB in 12,000 communities. The text of Mr. Wampler's letter follows; Mr. Kohler's letter to heating and plumbing companies is similar:

"Donald Nelson and the conservation division of the WPB have tackled the enormous job of digging out and moving such critically needed materials as iron and steel scrap, nonferrous metals, scrap rubber, rags, manila fiber, and other salvage materials that are essential to war production. In this task they need the active cooperation of American business and industry.

"A number of industrial leaders represented on this committee have undertaken to carry through the task of lining up industry behind the drive for salvage materials—so that the work of the conservation division may be supplemented and the job done thoroughly, quickly, and well.

"They have asked me to help organize the air conditioning industry—every company in our industry—to get behind the efforts of the War Production Board. This is a situation wherein by helping our government, we are also helping ourselves; because industry cannot do a satisfactory job of production without more scrap materials than are normally available. It has been standard practice with most of us to care for our 'production scrap,' but now something is needed beyond that. There is needed an extraordinary cleanup of our factories, involving recognition of the fact that if a machine or pipe line, a heating plant, a building—or what have you—is not absolutely essential for production at this particular time, then consideration should be given to scrapping it. If we don't win this war, most of our factories will be scrap anyway.

Get Your Scrap in the Fight!

Salvage for Victory

"The conservation division of the War Production Board has several sections working on the scrap problem; but we are talking about factories and industrial plants, and they fall under the industrial salvage section, which we are told is now operating in about 400 industrial communities. This section is doing a grand job in most places, but we take it for granted that in others they need some bolstering up; and in any event, it is our job to get back of the industrial salvage division and help put over their program.

"The task is about like this:

1) "If any given community where you have a factory has been organized by the industrial salvage section of WPB, and you are working actively with that effort, then you no doubt have appointed an executive in your factory or factories in such a city charged with the responsibility of cleaning up and putting back into the blood stream of production the vitally needed materials outlined in the first paragraph of this letter. In such case, we ask that you advise me of the name and title of the individual named in your factory—or factories—to conduct scrap operations so that we may announce your cooperation in the drive by our industry.

2) "If you have a factory or factories in cities that have not been organized by the industrial salvage section of WPB, we urge that you appoint an executive with the responsibility of doing the salvage job, and send us his name and title. We will see that this is reported to the industrial salvage section of WPB, and you will receive such assistance as they are able to render.

3) "Here is a chance for industry to do this job itself without the government sending around inspectors or agents, or using the power of requisition, and it is certainly up to us to make good on this basis.

4) "We urge that, you personally, or through a senior executive, take the initiative in the community or communities where you have factories with respect to all salvage operations applicable to farms, homes, stores, or any of the other like activities that are not directly associated with the industrial salvage campaign. The conservation section of WPB is doing a good job. It has already set up general salvage committees in 12,000 communities. Work with them. If they need help, please give them all the assistance you can.

"I would very much appreciate it if you will drop me a line and tell me in some detail what plans you have made or may make in this connection."

IDEAL BLACKOUT FACTORY ENVISIONED BY CONSTRUCTION EXPERT

GEORGE H. A. PARKMAN, Westinghouse construction expert, recently wrote his recipe for an ideal war factory—a blackout, bomb resistant, windowless building from which vital military machines and armaments would flow 24 hours a day, uninterrupted by air raids or sabotage. Drawing on American technical achievements of the past decade, Mr. Parkman advocated the use of artificial daylight by fluorescent lighting and precisely regulated temperature and humidity inside the arch roofed factory to raise to a maximum the efficiency of men and machines. A system of factory power supply designed to localize damage from bombing, sabotage and other causes, would assure an unbroken flow of electricity to lathes, drills, welding sets, and other equipment used to shape machines of war.

Two recent inventions would supply clean air to protect the health of workmen and guard delicate machine parts against scratching. One of these, an electric air cleaner, would bar the entrance of air borne dirt, dust, and smoke. The other, the sterilizing lamp, would stand guard in air ducts, killing bacteria with its invisible ultraviolet rays.

Although this factory would be adequate for the manufacture of almost any type of war equipment, its advantages are so great they would carry over into peacetime factory construction, inaugurating a new era in improved industrial working conditions.

Many of these engineering advances have already been incorporated in factories constructed in the past year, but no factory has yet been built to take full advantage of all these recent developments. Increased comfort of workmen and protection of health in such a factory would improve morale, and speed production by reducing lost time due to illness, according to Mr. Parkman.

Concrete "Egg Shell" Construction—The building would be made of reinforced concrete, with an arched "egg shell" type roof, to save time and steel and to provide a structure that would suffer least from bombing, sabotage, and fire. Although parts of the arched roof might be no thicker than 3 or 4 in., the structure would not lack strength, because it would have the same general shape as an egg shell.

This concrete construction costs about the same as steel frame construction, but requires only about 40 per cent as much steel, a vital war material, according to Mr. Parkman.

Setting a trap for germs—This scene inside the air conditioning duct of a large chemical plant shows a workman installing sterilizing lamps. Ultraviolet light from the lamps will kill 95 per cent of the bacteria in the air passing through the duct, thus purifying the air workers breathe and lessening the possibility of contaminating products

SIX POINT PROGRAM FOR SAVING FUEL

A SIX point guide to wartime fuel conservation was announced last month by J. W. Pauling, vice-president, Minneapolis-Honeywell Regulator Co. The six basic points are:

1) Prevent overheating and maintain uniform temperatures. Keep daytime temperatures to an even 68 degrees and turn the thermostat down to 50 at night.

2) Turn off heat in unoccupied rooms. Keep shades drawn and keep windows closed at night.

3) Do not waste hot water.

4) Install storm windows and repair or close openings around doors and windows to effect complete insulation.

5) Replace missing boiler or furnace insulation. Insulate the hot water heater.

6) If in doubt, call your heating contractor and check your heating plant.

Tests have shown that each degree the temperature is raised above 70 results in a 3 per cent increase in fuel consumption, according to Mr. Pauling.

WARTIME MAINTENANCE OF ELECTRIC CONTROL EQUIPMENT

ANY EQUIPMENT in daily use, and upon which industry depends for continuity of service, requires periodic inspection and maintenance. This is especially important in wartime, when plants are running at peak capacity and when top production depends upon continuous operation. Electric control is no exception to this rule. It is vital that controls be inspected regularly and replacements or repairs be made quickly.

Prerequisites to any good maintenance program are the proper selection and installation of the equipment. Assuming that the control device has been properly selected, installed, and adjusted, the maintenance program itself starts.

A first consideration in keeping control equipment in proper working condition is to prevent accumulation of dirt, oil, grease, or water on operating parts. It is, therefore, advisable to carry in stock protective paints for the stationary iron parts, and insulating varnish of the proper characteristics for the coils.

Where the air is saturated with moisture, or there are corrosive gases, it is well to inspect and paint the various control parts from two to four times a year, depending upon severity of operating conditions.

It is often desirable to add heaters or lamps within the controller enclosure to prevent excessive moisture condensation. Such heaters should be energized continuously, especially when the controller is not being used.

Circuit breakers or contactors are usually of rugged construction. Still, it is best to operate them by hand from time to time and check to make sure that all clearances are normal and that parts are working freely. Should parts become worn so that adjustments cannot be maintained, new parts should be used. Adjustment and cleaning, as well as renewal of the tips, depends upon frequency of operation. In the case of contactors, the armature should be cleaned and checked for free working and the condition of the magnet contact surfaces.

Occasional inspection should be made of all nuts and connection wires on panels and resistors, particularly when subject to vibration. Close inspection of pigtail connections should be made periodically since these are of finely woven wire for flexibility. In extremely corrosive atmosphere pigtail connections have been known to fall apart before there was any apparent indication of failure.

Float switches should be given the best of care, especially if they are of the moving contact type. The tips should be adjusted and lined up properly and, of course, cleaned if any indication of excessive corrosion is noted. The bearings should be made free to operate and any tendency toward binding should be corrected.

In float switches of the mercury contact type, the mercury tubes should be held tightly in place; if inspection shows that the tubes are becoming dark, it may be an indication of air leakage and the tubes should be renewed.

Trouble Shooting

Troubles are bound to occur in the best of equipment. Knowing what to do about them will save precious production time. If the fundamental cause of each trouble is understood the remedy will quite likely be apparent.

Periodic inspection and maintenance of electric control equipment is especially important in wartime, when plants are running at peak capacity and top production depends upon continuous operation

Contactors—A contactor has several bolted or spring closed contacts. Excessively high resistance at these contacts is the cause of the very high temperatures (100 to 200 C) that may be reached when the contactor is carrying rated current or less. The most likely point of high resistance is at the contact where the movable tip makes contact with the stationary tips.

However, high resistance may occur at any of the bolted joints on the contactor. Therefore, if one of these devices begins to develop an excessive temperature, a millivoltmeter should be used to determine which of the joints has a high voltage drop across it. An a-c millivoltmeter is available that can be used for checking the voltage drop on a-c contactors.

When the copper contact or contacts that have excessive drop across them have been located, correction can be made by opening the contact and removing the oxide with a file (not with sandpaper or carborundum paper). It is unusual to find a high resistance in a bolted joint unless the contactor has previously reached very excessive temperatures.

Since high resistance will most commonly be found in the active contact, it is a simple matter to inspect these tips weekly or monthly. If the temperature is unduly high, the tips should be given a few strokes with a file. If sulphur gas is present, a high resistance film will develop quite rapidly. To prevent this action, the contactor should be mounted in a tightly gasketed enclosing case, or immersed in oil.

The foregoing comments apply particularly to copper contacts because they oxidize readily, and the copper oxide formed has a very high resistance. Sometimes it is not practicable to keep the resistance of contacts low by filing them. When it is desired or necessary to maintain a low resistance of the active contact

without servicing, a silver face can be brazed to the two tips so that the contact is made through that metal. Silver will oxidize and the oxide has a higher resistance than the pure metal, but when heated, silver oxide has the unusual property of reverting back to the metallic form. Therefore, silver contacts are self-purifying.

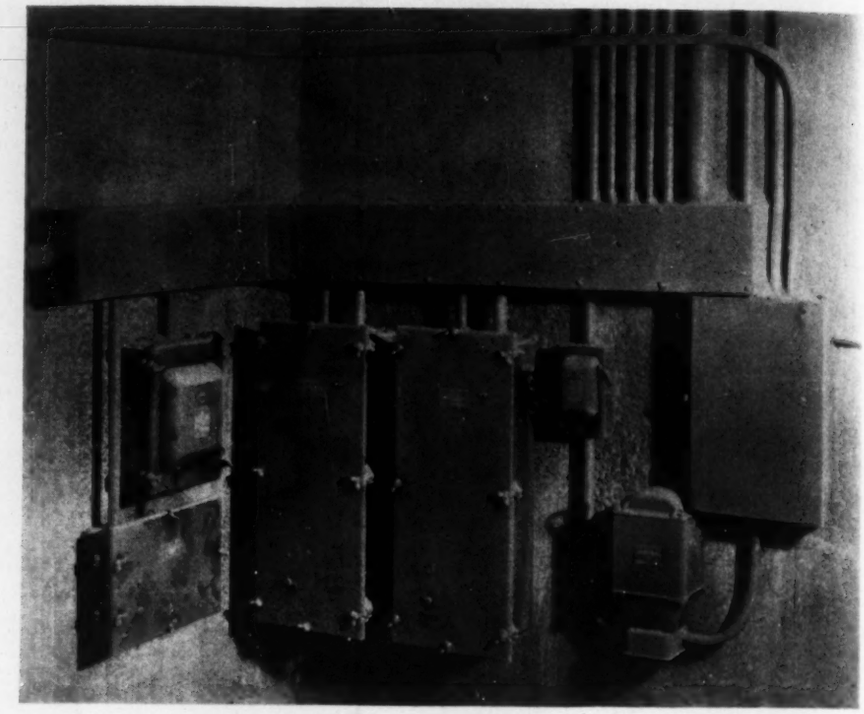
Electrical interlocks may fail to make circuit because of oxidation where copper contacts are used. Sometimes such failure occurs because dirt gets between the contacts. By using one hemispherical and one flat tip made of silver, both of these troubles will be overcome. The point of the hemispherical tip will make contact without trapping dirt particles between it and the flat tip, and the use of silver will overcome the oxide trouble.

Some maintenance men have the erroneous impression that contact tips that have been roughened by service should be smoothed so that they will carry the load. A roughened tip will carry current just as well as a smooth tip. Of course if a large projection should appear on a tip because of unusual arcing it should be removed. However, a tip that has been roughened by ordinary arcing need not be serviced. If a copper tip becomes overheated, this condition indicates that oxide has developed and should be removed.

A large percentage of contactor coil troubles can be traced to heating. Therefore, if the temperature can be reduced coil troubles can be decreased. Since the heating of a d-c coil will vary as the square of the voltage, and the heating of an a-c coil will vary about as the cube of the voltage, it follows that coils should be wound for the voltage that exists on the line. If the ambient temperature is high, this precaution is all the more important.

Preventing Coil Burnouts — When an a-c magnet, such as a solenoid, is supplied with constant voltage excitation it requires a large inrush of current to close the armature. When the armature closes the coil current drops to a normal value. Sometimes armatures may not close because of excess friction or for some other reason and the large inrush current may burn out the coil within a few seconds.

Such mishaps can be prevented by the use of a thermal cutout to protect the coils. When the thermal cutout opens because the armature fails to close, it is merely necessary to replace a small link made of two pieces of metal held together by a low melting point solder.



The surrounding atmosphere determines to a great extent the proper type of enclosure to be used. These starters are installed in a grain elevator, and are protected by special dust-tight enclosures

Resistors—Resistors are important auxiliaries and are of several types, such as porcelain tube, enameled resistors, open wound, wire resistors, strip wound, cast grid, etc.

Cast grids are usually assembled and held together by being clamped on a tie rod. The current passes from one grid unit to another across a ground face. When too much current, say several hundred amperes, is made to flow across these ground surfaces, they may develop high resistance and destroy the joint.

To overcome this difficulty, these joints should be cleaned and the current path paralleled. This procedure will reduce the current in the middle joints, where the trouble usually occurs or is most likely to develop.

Edge wound or strip resistors usually have their terminals either brazed or welded to the strip, which prevents excess resistance from developing at this joint. In order to provide an adjustable contact on this type of resistor, a clamp type of terminal is sometimes furnished. However, since the resistor may become quite hot at this point, a bad contact is very likely to develop. Therefore, if one does develop, the best cure is to braze the terminal at the proper position.

The high resistance cast grids that have a small cross sectional area sometimes give trouble because of breaking, especially if they are mounted on machines that vibrate severely. A correction for this trouble is to use an edge wound resistor, which is nonbreakable. This type is made of corrosion resisting material that is capable of withstanding high temperatures without scaling.

Relays—The function and importance of relays are too well known to need discussion; to cover all the relays used would be an endless task because there are many varieties of them. A number of relays have been designed to operate as a function of time. The one that was designed first to operate on a time basis was the dashpot type. Movement of a solenoid is retarded by means of a dashpot, giving a time-current relation that is called an inverse time characteristic.

If trouble is experienced due to tripping while starting a motor or shortly after getting up to speed,

there are three things that can be done:

1) A heavier oil may be used if the relay almost holds.

2) A starting contactor can be used that does not include the overload relay in the circuit. After the motor is up to speed, the running contactor can close and the starting contactor can open, connecting the overload relay into the circuit. This is a rather complicated method, but it is sometimes used.

3) The final alternative is to replace the dashpot with a temperature type of overload relay. This is one of the reasons why the temperature type overload relays were originally developed.

Temperature Overload Relay—Since the function of a temperature overload relay is to protect a motor under all ambient temperatures, its final temperature should be the same as that of the motor—which is 90 C. This means that a motor can have a 50 C rise in a 40 C ambient.

Therefore, the relay should just trip if placed in a 90 C ambient, or in a pail of water held at that temperature. If a relay does not function correctly, it should be immersed in a pail of water kept at 90 C and adjusted so that it will. The adjustment should not be made by bending the thermoflex strip. If this method of checking or adjustment does not provide the necessary degree of protection to the motor, it can be assumed that the size of the relay heater is not correct.

A temperature overload relay does not need any such maintenance attention as outlined for dashpots, but its use does involve the observation of certain precautions. Since it is sensitive to temperature, it should not be put in a strong draft, such as that from a window or a circulating fan. If it is necessary to place it in such a position, it should be shielded by a cover.

Conversely, a temperature overload relay should not be situated above a source of heat, such as steam pipes. In brief, the relay should be in an ambient temperature that does not differ greatly from that of the motor.

Time Delay Relay—The third type of relay is used for controlling the rate of acceleration of motors and for many other functions where a short time delay is needed. In the escapement type of relay, a pendulum is used as the governing means, which makes it necessary to mount the relay in a definite position with respect to the motion of the pendulum.

It is not always possible, however, to mount the relay in the proper position, and when it is in the out of true position it is less dependable. Shortening the pendulum makes it possible to tip the relay further from the vertical, but the shorter pendulum results in a shorter time delay.

To overcome this limitation a new design that has a balanced pendulum has been made available. The variation in time is obtained by changing the length of the stroke. In principle the two devices are the same, but mechanically they are quite different.

If the older type of escapements fail to time properly, their mounting position should be checked. However, if the application is such that it is difficult to mount and keep the relay in the proper position, consider use of the balanced type.

When Corrosive Gases Are Around—Corrosive fumes in many plants, such as those manufacturing rayon, coke, sulphuric acid, nitric acid, chlorine, and so on, rapidly attack the metal parts of control devices. To overcome this trouble, the operating parts are frequently immersed in oil in a container capable of withstanding the corrosive atmosphere. The container is made either of cast iron or of heavy boiler plate steel, which is given a protective coating of a paint that is capable of withstanding the fumes or gases encountered.

When it is impracticable to oil immerse a given type of control, the equipment is enclosed in a heavy case with a tight, gasketed cover. The enclosing case is protected with a suitable corrosion-resisting paint. —E. H. ALEXANDER, engineer, industrial control division, General Electric Co.

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Shipyard Pipe Shop Streamlines Fabrication for Liberty Ships

New Methods Developed by Oregon Shipbuilding Corp. Speed Pipe Bending and Other Operations .... By R. S. Jones

SUMMARY—Mr. Jones, of marine pipe control, Oregon Shipbuilding Corp., describes here the piping services for Liberty ships—essential products of the U. S. Maritime Commission's "ships for victory" program. . . . There are some eight and a half miles of piping aboard one of these vessels; roughly, the piping services can be classified as fuel oil, lubricating oil, salt water, fresh water, and steam and exhaust systems, plus various miscellaneous lines. In order to keep pipe fabrication up with the production schedule of the rest of the yard, new methods of pipe bending and performing other fabrication operations have been inaugurated in the pipe shop. . . . This description of the new procedures will be of interest not only to shipyards and fabricators of ship piping but also to contractors not engaged in shipbuilding, for it has been suggested that one way of speeding our ship program may involve increased prefabrication of ship piping wherever facilities are available in contractors' shops. . . . Standardized design of the Liberty ships allows more extensive prefabrication of piping than would otherwise be possible.

THE EC2-SC1, or Liberty ship, is a single screw cargo vessel essentially simple in its lines and designed to perform at maximum efficiency under all conditions. The ship was designed primarily for construction and use under emergency conditions that require speedy building, and yet to be an efficient, seaworthy vessel that will satisfy the rigid requirements of the Maritime Commission. The vessel has a total displacement of 14,100 long tons, and is powered by a three cylinder direct acting, surface condensing, triple expansion marine engine.

8.5 Miles of Piping

All sizes and types totaled, there are approximately 8.5 miles of piping aboard one vessel and the number of valves and fittings runs far into the thousands. Unless the line operates under high pressure or high temperatures, the piping under 1½ in. has screwed joints. The rest of the piping is flanged. Any line carrying salt or fresh water, or exposed to the elements, is galvanized. Piping is direct as practical with a minimum number of bends and enough joints to provide easy accessibility.

There are 31 systems of piping on the Liberty ship, each named according to its service and, with few exceptions, entirely dependent upon one another for operation. The systems can be roughly divided into five separate classifications: fuel oil, lubricating oil, salt water, fresh water, and steam and exhaust.

The main fuel oil system is titled "fuel oil transfer and oily ballast," and is so combined that it can either carry fuel oil from or to the storage tanks, or when necessary fill and empty the tanks with water ballast. This system is constructed of 5 and 6 in. standard black pipe and has a working pressure of 50 psi and a working temperature of 100 F.

Fuel oil service carries fuel oil from the tanks to the burners and has the highest working pressure of any of the systems on the ship (450 psi). It is constructed of extra heavy seamless drawn black pipe running in sizes from ½ to 1½ in.

The only other system coming under the fuel oil classification is the overflow system, a galvanized line taking care of any possible overflow from the fuel oil tanks.

Under the heading of lubricating oil systems comes only one line, filling and draining for miscellaneous tanks, a low pressure line supplying the various oil service tanks throughout the vessel.

The salt water systems comprise several minor systems all emanating from one major system, entitled "salt water suction and discharge." The salt water systems have several duties, such as providing circulating water for the main engine and the propeller shaft, salt water for sanitary services, pumping bilge from all holds and machinery spaces, taking care of all drainage from the deck, and providing water for the fire systems. Standard galvanized pipe is used on the salt water systems, which operate under 50 psi working pressure.

The fresh water system provides water for the galley, all wash basins, drinking fountains, and baths. It is a galvanized line using pipe with screwed joints running from sizes 1½ down to ½ in.

The steam and exhaust systems comprise the greater percentage of piping systems on board the Liberty ship. Under this classification come two major systems, main steam and auxiliary steam, and their various satellites.

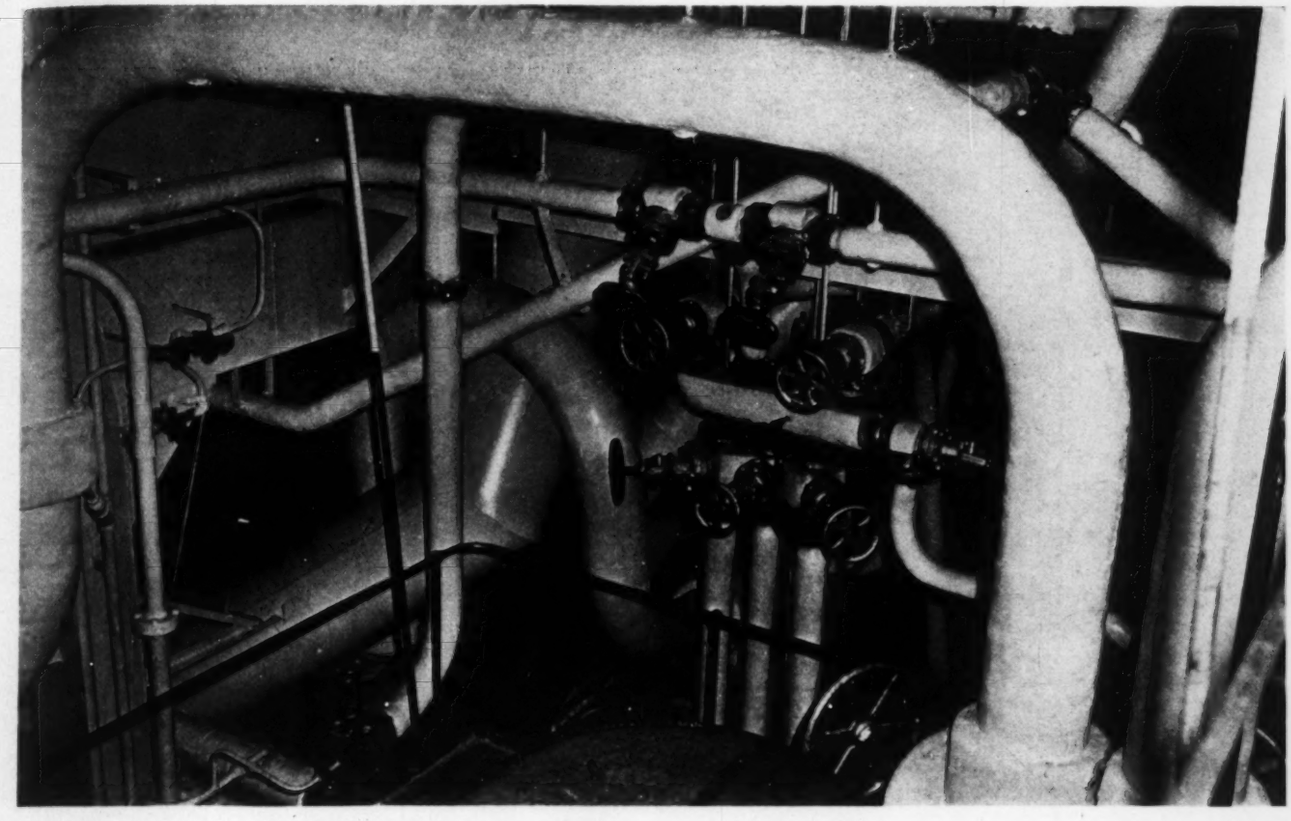
Main steam is a superheated line running from the superheater outlet of each boiler and uniting into a common main leading direct to the throttle of the main engine. Main steam is a 6 in. standard seamless drawn line which operates under 220 psi working pressure and 450 F.

Auxiliary steam furnishes saturated steam to the engine room auxiliaries (steam to the deck machinery, to the steering gear, to the fuel oil heaters, to the evaporator coils, to the ship's heating systems, and to the steaming out and smothering systems). These engine room auxiliaries exhaust into a continuous main to the exhaust heater. The auxiliary steam systems are run with standard seamless drawn pipe and have a working pressure of 300 psi and a temperature of 400 F. The exhaust lines are standard black pipe under 12 psi working pressure and 245 F working temperature.

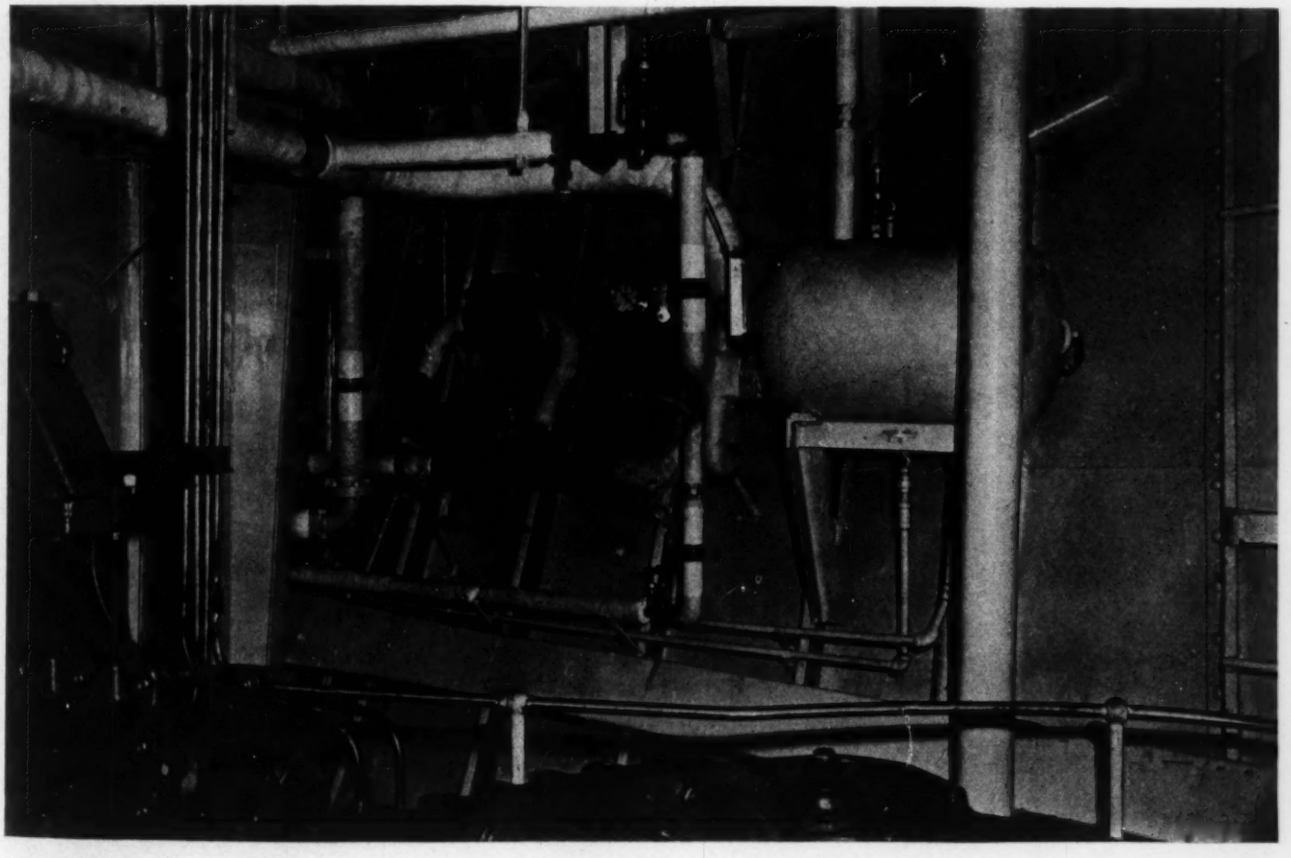
There are, of course, several other piping systems that do not come under the above classifications, such as refrigeration stores, CO_2, telemotor piping, etc. However, the above five classifications give a general idea of the piping aboard the EC2-SC1.

The Pipe Shop

The pipe shop at Oregon Shipbuilding Corp. is a two story building, 60 × 300 ft, with the first floor devoted entirely to the cutting, bending, welding, and testing of pipe. The second floor comprises the pipe assembly, where certain



Some of the piping on a Liberty ship. *Above*—Engine room center, aft of boilers, showing main steam piping and atmospheric exhaust lines. . . . *Below*—Aft steering gear room, showing sanitary fresh water tank on starboard side, with auxiliary steam and exhaust piping lines. Small lines are telemotor piping



specialized units of systems are set up, jointed, and sent down to the hulls for installation.

With but few exceptions where the pipe is heated and bent on the slab, all of the 1243 bends required per ship are bent cold on the six bending machines in use in the pipe shop.

In the early days at Oregon Shipbuilding, pipe was bent system by system and much of the pipe was bent according to template. The pipe department soon found that if it was to maintain the installation pace set by the other departments in the yard, several drastic changes would have to be made in the fabrication methods then in use.

A conference of the heads of the pipe department resulted in several unprecedented changes in methods. A time study revealed that much time was being expended in the use of bending by template and even after the bend was made, it would not fit the specifications required. At the same time, a study of the methods in use revealed that too much time was being lost in the changing of dies to meet the many sizes of pipe required on each system.

New Methods

The conference resulted in the discard of template bending and a complete change over from system by system bending to a bending by size and radius, with complete disregard to system and hull.

For example, instead of bending all of the auxiliary steam piping required for one hull, the bending machine would set up a die for 4 in. pipe with a 20 in. radius, and would then bend all the 4 in. pipe with a 20 in. radius required, not only for auxiliary steam but for all systems throughout the ship. With this procedure in force, each size and radius of pipe was bent not only for one hull but for six hulls at the same time. After this new procedure was tested out and found feasible all bends used in a hull were grouped according to size and radius. Then a cycle of production was set up to match the production schedule of the yard in general. It was found that to meet launching and delivery schedules, and still build up a surplus stock of bent pipe (the pipe shop fabricates for surplus stock instead of for direct installation), a complete cycle of bending would have to take place every two weeks.

Streamlined

With this new sequence of pipe bending in operation, it was found that pipe fabrication could more than keep up with the construction schedule of the rest of the yard; nevertheless, it was necessary to cut down on the spoilage of pipe and re-bending. To force further efficiency, a streamlined fabrication procedure was inaugurated with several new twists.

The pipe is brought in one end of the shop in raw lengths and is given a preliminary cut, allowing three or four inches for bending. It is then taken to a bending machine where it is bent according to detailed blueprint.

In an effort to bend the pipe exactly as required and still be able to turn out bends at top speed, an oversize "protractor" was constructed and fastened to the top of the die on the bending machine. This ingenious device is constructed with a movable arm or pointer which can be set at the degree of bend required on the drawing. For example, a piece of pipe requires a 30 deg bend. The pointer of the protractor is set at 30 deg and the bending operation then starts. When the pipe has been bent to 30 deg it comes to rest flush against a vertical arm, indicating that the pipe now is bent to 30 deg. The protractor is so constructed as to allow for the spring back of the pipe after the pressure of the block is released.

Even with the use of this protractor, bends sometimes vary as much as ½ in. Rather than have the men operating the benders stop production and check each piece for correct specifications, the piece is sent to the slabs, where a soapstone outline of the pipe has been made, with rigid pipe chairs placed along one side of the outline. The pipe is then set down in the chairs. If the piece does not meet the exact specifications, it is heated with a torch and is bent by hand right as it lies on the slab. (Only in about one in every 20 pieces is this correction procedure necessary).

While the piece is still on the slab it is cut to exact measurement (to make up for the preliminary cut) and the flanges are tacked on. (To get an exact fit, a "headstone" is used in tacking the flanges on).

From the slab the piece is sent to the weld room, where the welding of the flange is completed.

With the completion of the welding the pipe is then sent to the storage yard. (Except where screwed flanges are used, a pressure test is made before the pipe is released.) Once in the storage yard the pipe is racked according to size and type where it awaits delivery to the hull.

Specialists

Probably the greatest achievement in pipe shop operation is the handling of the pipe itself. Each man in the shop has a special operation, whether it be reading the bending protractor or painting the identification number on the pipe. All pipes, in their trips down the assembly line, are handled by overhead cranes and every fabrication operation is smooth and precise.

Every day, shipbuilding records fall at Oregon Shipbuilding Corp., and to maintain its part in the production rate, the pipe shop finds it necessary always to be searching for new and faster fabrication methods —methods that will furnish pipe in sufficient quantities, yet deliver pipe that will satisfy the strict installation requirements of the USMC.

OREGON SHIP BREAKS ALL BUILDING RECORDS

All shipbuilding records were broken last month when Henry Kaiser's Oregon Shipbuilding Corp. launched a Liberty ship just 10 days after its keel was laid. The launching broke the 24 day record, which was set a month earlier, held by Mr. Kaiser's Richmond, Calif., yard.

It was emphasized by company officials that there had been no disruption of routine production during the record-breaking construction.

INDUSTRIAL HEALTH DEFENSE

How to Make Dust Counts

By N. R. Bernz

SUMMARY—Considerable attention has been focused in recent years on the conservation of health in industry, a subject of increased importance because of the vital need for all-out war production. Mr. Bernz, of the Fidelity and Casualty Co. of New York, discusses the methods employed in the evaluation of dust exposures, reviewing the types of sampling and counting instruments and the various factors involved. . . . In March he covered the Greenburg-Smith impinger—best known of the sampling devices—and the Sedgwick-Rafter and Hatch cells for dust counting. In June, he discussed the midget impinger, the microprojector, the Owens jet, the B. & L. dust counter and the konimeter. . . . In his concluding article this month, information is given on the choice of dust counting instruments, methods of sampling, and evaluation. A table summarizing the multiplication factors for various dust counting instruments is included. . . . His material is based on a paper read before the Greater New York Safety Congress

METHODS OF calculation for various dust counting instruments, and the multiplication factors influencing the dust counts, are shown in the accompanying table. It should be emphasized that in preparing this table for the sake of comparing the various methods, certain typical conditions had to be assumed in some instances and that many other combinations are possible.

In reviewing the table and comparing the mathematical factors affecting the dust counts as obtained by the various methods, it is obvious that even reasonably small deviations in the actual counting will result in sizeable errors that may extend into millions in the final calculations. In recording dust counts, therefore, the possible degree of accuracy should be determined with respect to the tabulated factors, and only the required number of significant figures should be included.

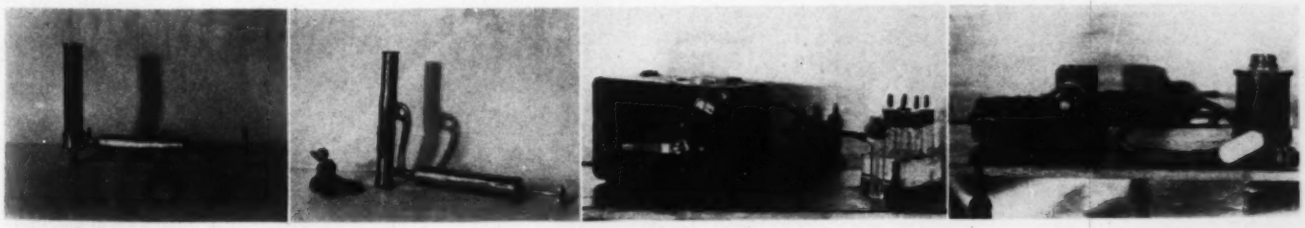
It also appears that the accuracy of the final dust values recorded by the various methods so far as quantification per se is concerned, is not significantly greater or lesser for one process than another, within certain concentration ranges. An exception is the microprojection technique on impinger samples and possibly the konimeter. Long range air samples resulting in low water to air volume ratios, counted without dilution by the microprojector, require relatively small factors as indicated in the table. A close second is the konimeter method, if we are to accept Mavrogordato's classification to the effect that concentrations in the microscopic field which are heavy enough to result in dust counts in the 10-15 million class after the mathematical factor has been applied, are still "easy to count." Of the two, however, the microprojector has a longer range. While a factor in the class of 0.05×10^6 applies only up to about 14 million with the konimeter method, it is applicable for a concentration of 25 million with the former. The same thing applies when compared to other methods. A factor of 0.2×10^6 used on impinger samples in the 10 million class, with the direct microscopic method, may be applied in concentrations up to 100 millions in the microprojector.

At this point it might be appropriate to emphasize that when speaking of accuracy of dust count in this connection, I am referring strictly to evaluation of the dust samples as taken, and not of a true dust count so far as the dust exposure is concerned, in which the efficiency of the dust sampling device and a number of other factors should be taken into consideration.

Choice of Method

So far as the sampling instruments are concerned, one with a large sampling capacity—as the standard impinger, for instance—naturally furnishes a more representative sample than any one of the grab samplers. Numerous attempts have been made to correlate the different instruments so that the counts of one could be interpreted in terms of another, but without much success. This would have been highly desirable, in view of the fact that most of the data pertaining to lung pathology in connection with dust exposures in this country have been correlated with dust counts obtained by the Greenburg-Smith impinger.

While it is true that the various instruments have varying efficiencies, and that it is very doubtful that any one device reaches the 100 per cent mark (although such claims have been made), a correlation should be possible provided the efficiencies remain constant. This is not the case, however, as studies have revealed that the collecting effi-



***Left to right*—Owens dust sampling apparatus. . . . Hill dust sampling apparatus. . . . Midget impinger. . . . Thimble dust sampling apparatus (Photos courtesy division of industrial hygiene, New York State Department of Labor)**

Methods of Calculation for Various Dust Counting Instruments, with Multiplication Factors

(C x Factor = Dust Value in Particles per Cubic Foot)

METHOD	INSTRUMENT	PARTICLES PER CUBIC FOOT =	FACTOR	C	CONDITION
1	Impinger and direct microscopic counting	$C \times \frac{4000 \times cc^*}{cu\ ft}$	0.2×10^6	Average count per 1/4 field	75 cc sampling liquid, 15 cu ft of air and a concentration in the 10 million class, i.e., requiring a dilution of 10 times
2	Midget impinger and direct microscopic counting	$C \times \frac{4000 \times cc^*}{cu\ ft}$	0.2×10^6	Average count per 1/4 field	10 cc sampling liquid, 1 cu ft of air and a concentration in the 10 million class, necessitating a dilution of only five times with this method
3	Microprojection method on impinger samples	$C \times 2 \times 10^5$	0.2×10^6	Average count per 0.05 square millimeter counting area as projected on the translucent screen	Water to air volume ratio of 10.** Counting area of 0.05 square millimeter
		$C \times 5 \times 10^4$	0.05×10^6	Average count per 0.05 square millimeter counting area as projected on the translucent screen	Water to air volume ratio of 2.5** Counting area of 0.05 square millimeter.
4	Owens jet	$C \times 2.83 \times 10^5$	0.28×10^6	Average count in one ribbon	One stroke (i.e., a 50 cc air sample) and such a magnification that the length of the dust record is 500 times the width of the ribbon counted
5	B & L dust counter	$C \times 10^5$	0.1×10^6	Average count in one ribbon	One stroke, i.e. 28.3 cc air sample
6	Konimeter	$C \times 5.7 \times 10^4$	0.06×10^6	Average count over four 9 deg sectors	One stroke, i.e. 5 cc air sample

*cc in these calculations is volume of original sampling liquid.
**The water to air volume ratios given are on the basis of cc of water to cu ft of air.
Note: Above derivations are based on microscopic combinations as described in the text, and one millimeter deep cell for the impinger methods.

ciency of an instrument is a mathematical function of the size variation. Another factor which probably plays just as important a role in the lack of coordination of dust counts as obtained by different devices, is the fact that the dust dispersion of an industrial process is seldom or never constant. It usually varies from moment to moment and for this reason the difference between the dust values secured by means of a grab device and those representing large volume samples integrated over relatively long periods of time, are bound to vary. Gurney et al [see Journal of Industrial Hygiene and Toxicology, January, 1938], who made comparative studies of dust samples taken with the impinger and the Bausch & Lomb dust counter, have shown that the ratios between the dust counts obtained with the two methods vary greatly with the size range of the dust sampled.

When comparing a grab sampling instrument with the impinger in a dust exposure which varies greatly from one moment to another, it may well happen that the various "shots" of the grab sampler synchronize with the top or bottom of the dust dispersion pulsation curve, while the impinger, with its long range samples, catches both extremes and its dust value results in an average. Therefore, even if the size range were such that a constant efficiency could be maintained for the two instruments, the first case would result in one ratio while the second case would show another.

Purpose of Counts

In the choice of a dust sampling instrument, the purpose for which the dust recording is to be made should be the guiding factor. If an appraisal of a dust hazard is to be made, the dust concentration should be determined by instruments and methods on which safe limits and codes are based. In the case of a dust exposure in which an occupational disease hazard is involved, the sampling should preferably be done with the impinger, since practically all data by means of which such exposures may be evaluated are based on this instrument.

For purposes such as periodic checking of the performance of dust control systems, or other tests of a similar nature, almost any convenient dust sampling device is satisfactory. Since portability and simplicity in operation with respect to both sampling and counting are about the only requirements, the grab samplers with microscopic arrangements lend themselves readily to this type of work. A fairly constant collecting efficiency is naturally a criterion for a dust sampling device used to compare the degrees of dustiness of a plant from time to time. As stated above, it is not always possible to attain such a constancy due to a number of varying conditions, but with intelligent application the effect of this instability may be minimized. The konimeter, for example, has been used extensively and with great success in dust control work in the mines of South Africa.

Microscope

The type of microscopic combination used in dust counting also greatly affects the counts. The important factors in this respect are the magnification and illumination, i.e., the type of condenser employed. In the writer's experience with a light field setup consisting of an Abbé condenser, a 7 x eye piece and a 10 x objective, and a dark field combination of a dissecting condenser, a 30 x eye piece and a 10 x objective, ratios between dark field and light field counts as high as 50 have been recorded for industrial atmospheres. In other words, 50 times as much dust has been found by one method as with the other on the same samples. This tendency toward higher counts when the observation was made under dark field microscopy with higher magnification, has also been shown in the studies of Hatch and Pool, published in the Journal of Industrial Hygiene and Toxicology, vol. 16, p. 177 (1934).

Since this is due to the fact that the limit of visibility of the dark field method described above is much lower, microscopically speaking, than that of the light field, it is evident that theoretically, at least, such a ratio is unlimited. This can be shown mathematically: If all the dust in a sample is of such a small size that it cannot be seen by the standard light field method, i.e., the light field count = 0, the ratio of dark field to light field counts becomes infinity.

The Sample

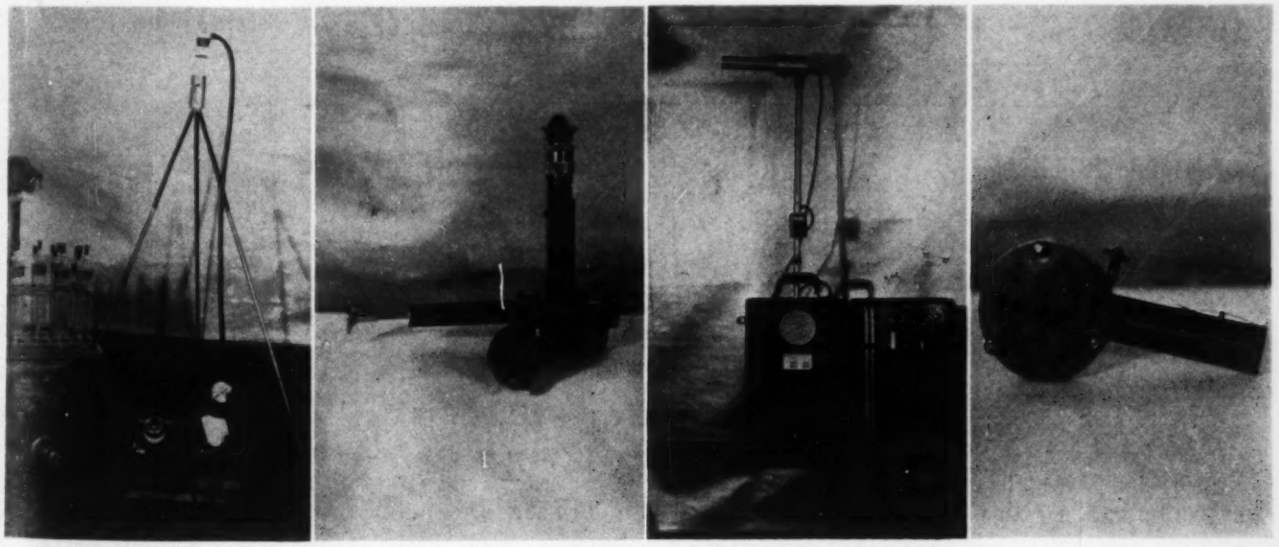
Regardless of the type of sampling instrument used and the microscopic method employed in the quantification process, in view of the variation in industrial operations with the consequent change in the rate of dust dispersion, it is evident that a single dust count has little or no meaning. For proper rating of any dusty industrial process with respect to its pathology producing potentiality, frequent sampling and dust evaluations should be made.

The position of samples in order to secure the most representative location with respect to dust dispersion is very important. Correct labeling of dust samples in reports is necessary for proper interpretation. Breathing zone samples, i.e., samples taken close to the nose of a man engaged in a dusty operation, are evidently much higher than those taken in the general air of the work room. Only one man, however, may be exposed to the higher concentration thus recorded, while a great number of men may be encountered in the atmosphere represented by the general air dust count. Both types of counts are therefore important as an indication of various conditions, and emphasize the importance of specifying the positions where the different samples are taken.

Another item of great importance in the evaluation of dust samples collected in a liquid, is the time interval that elapses between sampling and counting, i.e., the age of the sample. Flocculation of dust particles into large aggregates, thus decreasing the original numbers, takes place rapidly as the sample is permitted to age. The rate of flocculation varies for different types of dust; thus, for instance, foundry dust flocculates much more rapidly than that of granite. Regardless of the type of dust, however, counting should be done as quickly as possible after sampling in order to eliminate excessive flocculation, and a time limit of 24 hr should preferably not be exceeded. This rule also helps to minimize the reduction in original particle numbers due to the solubility of the dust, which in some instances may be quite a factor. All this naturally applies only to instruments in which the dust is collected in a sampling liquid, as in the impinger.

Other Factors

A great many other considerations should be taken into account in order to obtain as accurate an evaluation as possible. Such considerations include proper cleaning of dust counting cells and sampling devices, adequate agitation of dust samples in liquid suspension to secure a representative portion in the counting cell, the technique of filling cells, counting of a sufficient number of cells and fields in each cell to obtain a representative average, proper settling period in the cell be-



***Left to right*—Large impinger. . . . B. & L. dust sampling apparatus. . . . Electrostatic dust and fume sampler. . . . The konimeter (Photos courtesy division of industrial hygiene, New York State Department of Labor)**

fore counting, deduction of proper control counts, etc.

Another factor which within certain limits undoubtedly influences the degree of error in dust counting to not a very small extent, is the experience of the man doing the dust counting. The inexperienced counter usually exhibits a tendency to report much lower dust values than the one who has had more microscopic experience. Unfortunately, however, it is not practical to define any standard requirements which should be applied in order to minimize this factor.

What to Report

In reviewing all of the above conditions that may affect the size of the errors in dust counts as reported in industrial hygiene surveys, it is evident that it is not always feasible to scrutinize all these items in the evaluation of a dust exposure. It should be equally clear, however, that there are certain fundamental requirements that should be defined whenever a dust count is recorded. Of conditions that should be specified, the following are probably the most important.

1) The type of sampling instrument used.

2) The microscopic setup employed in making the quantitative determinations. This should include the magnification, size of field, and type of condenser.

3) Time that elapsed between the dust sampling and counting of impinger samples.

4) Location of samples, with emphasis as to whether they are general air or breathing zone samples.

5) The composition of the dust. If siliceous, the percentage of free silica should be defined.

For the complete appraisal of the hazard involved additional information is necessary, such as number of men exposed, duration of exposure, respiratory protective devices worn, etc., the description of which is beyond our scope here.

ASA APPROVES TWENTY-THREE ASTM STANDARDS

THE AMERICAN Standards Association recently announced approval of 23 standards and specifications developed by the American Society for Testing Materials. Seven deal with wrought iron and wrought steel pipe and tubing; 12 cover specifications for testing materials for boilers, pressure vessels, flanges and boltings, locomotives, etc.; two cover malleable iron castings and cupola malleable iron; and two deal with fabricated steel bars and welded steel wire fabric for concrete reinforcing.

Among the standards of particular interest to HPAC's readers are:

Boiler Rivet Steel and Rivets (ASA: G28.1-1942; ASTM:A31-40)

Carbon Steel Plates for Stationary Boilers and Other Pressure Vessels (ASA:G29.1-1942; ASTM:A70-39)

Low Tensile Strength Carbon Steel Plates of Flange and Firebox Qualities (ASA:G30.1-1942; ASTM:A89-39)

Carbon Silicon Steel Plates of Ordinary Tensile Ranges for Fusion Welded Boilers and Other Pressure Vessels (ASA:G31.1-1942; ASTM:A201-39)

Chrome Manganese Silicon (CMS) Alloy Steel Plates for Boilers and Other Pressure Vessels (ASA:G32.1-194 ; ASTM:A202-39)

Low Carbon, Nickel Steel Plates for Boilers and Other Pressure Vessels (ASA:G33.1-1942; ASTM:A203-39)

Molybdenum Steel Plates for Boilers and other Pressure Vessels (ASA:G34.1-1942; ASTM:A204-39)

High Tensile Strength Carbon Silicon Steel Plates for Boilers and Other Pressure Vessels (ASA:G35.1-1942; ASTM: 212-39)

Alloy Steel Castings for Valves, Flanges, and Fittings for Service at Temperatures from 750 to 1100 F (ASA: G36.1-1942; ASTM:A157-41)

Forged or Rolled Alloy Steel Pipe Flanges, Forged Fittings, and Valves and Parts for Service at Temperatures from 750 to 1100 F (ASA:G37.1-1942; ASTM: A182-40)

Forged or Rolled Steel Pipe Flanges for General Service (ASA:G46.1-1942; ASTM:A181-37)

Lap Welded and Seamless Steel and Lap Welded Iron Boiler Tubes (ASA: B36.12-1942; ASTM:A83-40)

Electric Resistance Welded Steel and Open Hearth Iron Boiler Tubes (ASA: B36.13-1942; ASTM:A178-40)

Seamless Steel Boiler Tubes for High Pressure Service (ASA:B36.14-1942; ASTM:A192-40)

Medium Carbon Seamless Steel Boiler and Superheater Tubes (ASA:B36.15-1942; ASTM:A210-40)

Spiral Welded Steel or Iron Pipe (ASA:B36.16-1942; ASTM:A211-40)

Seamless Alloy Steel Boiler and Superheater Tubes (ASA:B36.17-1942; ASTM:A213-40)

Electric Resistance Welded Steel Boiler and Superheater Tubes for High Pressure Service (ASA:B36.18-1942; ASTM:A226-40)

All of these standards are available from the American Standards Association, 29 W. 39th St., New York, N. Y., at 25c per copy. They can be ordered singly or in sets.

COMPRESSORS TO BE TAKEN FOR WAR PLANT USE

Lessing J. Rosenwald, director of the conservation division of the War Production Board, announced at a meeting of department store interests last month that air conditioning compressors in sizes 100 hp and larger are to be taken from various department stores, hotels, theaters, and office buildings all over the country, for use in plants needing such equipment to produce synthetic rubber, high octane gasoline, and other war needs. According to a letter from Donald Nelson, which Mr. Rosenwald read, it will probably be necessary to acquire existing equipment in sizes 100 hp and larger from practically all hotels, office buildings, theaters, and buildings of like character. Tremendous quantities of compressors are needed, according to Mr. Nelson, and could not be built in the short space of time available for the completion of the various projects.

A number of stores have volunteered their refrigerating equipment, and similar requests are to be made by the WPB of other users of refrigerating equipment, it is understood. The news was no surprise to many users of air conditioning, some of whom had received inquiries on the matter, and who are familiar with the many wartime applications of air conditioning.

How to Organize and Carry Out a Factory Scrap Campaign

A SALVAGE program in a plant, factory, shop, or yard must be based on the fact that industrial salvage and conservation form the backbone of the War Production Board's campaign to put the nation's waste back into production. Unless American industries take on the major job of making broken down, dismantled or unusable materials available for scrap, the national supply of steel for manufacture of war equipment will be endangered. For, if steel mills are not assured of an adequate supply of scrap, they cannot continue to keep up production of the steel which goes into planes, tanks, guns, and ships we need to win the war.

Such factors as type of work and the size of plant partially govern the organization of a company's salvage operations. But common methods of organization of a scrap campaign, collection, segregation, and disposal are available to all.

Salvage Manager—First, the organization to operate an effective salvage collection need not be elaborate or costly. It works best when it is simple and unencumbered with extra officials and unnecessary steps. An able executive of the company should head it up as salvage manager. He should work with superintendents and foremen in various departments. He must be armed with ample authority to make decisions to scrap unused material.

Survey—To start the ball rolling, these men should make a survey of their departments and report to the salvage manager machines and equipment which are obsolete or out of active production. The salvage manager should make a written report of these findings as a basis for action.

Yardstick—It is management's function to mark and send to the scrap heap equipment that is obsolete. After inspection, use this yardstick in coming to a decision: If a machine or other piece of equipment hasn't been used for three months, and if it can't be proved that it will be used in the next three, turn it over where it can be used . . . or scrap it. Either dispose of equipment in industry if there is a call for it, or put it to work as scrap for the weapons of war.

Classification—Once such equipment has been marked for scrap, a responsible shop man should supervise its dismantling and classification. The assortment may be made to yield valuable replacement parts for machines in operation. Cutting down the need for purchasing new parts will remove the plant from the competition for equipment.

Promotion—No salvage campaign can be successful without the wholehearted cooperation of every person in the plant. Remember that even the most worthwhile cause needs the proper promotion to put it across. The battle for scrap to keep our production going is dramatic enough to put over with a bang. Stunts, posters, billboards, and frequent mention in company publications or house organs are excellent vehicles for capturing and sustaining employees' interest in the program. In most plants, excellent talent can be recruited for this promotion from among the employees.

Suggestions—Workers should be urged to contribute suggestions and ideas for increasing salvage output. These may either be cleared through the foreman or written on slips and deposited in a suggestion box. Occasional rewards and incentives for outstanding cooperation in the salvage campaign will bring out employee initiative. Workers can make or break a program. If their enthusiasm is enlisted and maintained, they will prove collaborators who will match the efforts of management.

Bins—Bins and containers—preferably displaying a poster or a slogan—should be placed in strategic spots throughout yards and plants. These serve as depositing places for production scrap, salvaged waste materials, and contributions which workers bring from their homes. Separate containers for dif-

10 SUGGESTIONS FOR GETTING OUT INDUSTRIAL SCRAP

1) Head up the campaign by appointing an able executive of the company, armed with authority to act.

2) Use posters, illustrations, pay envelope stuffers, and all other publicity means to enlist all employees in scrap campaign.

3) Comb plant and yards for dormant scrap and unusable and abandoned equipment.

4) Survey all plant equipment, particularly idle, standing, or discarded machines.

5) Classify and segregate scrap and supervise its handling.

6) Make each foreman responsible for preventing spoilage and waste in his department.

7) Report promptly equipment which is obsolete. If equipment has not been used in three months, and it can't be proved that it will be used in the next three, turn it over where it can be used . . . or scrap it.

8) Salvage usable parts from equipment marked for scrapping.

9) Speed return of scrap to mills and refineries through existing channels. Report regularly on collections of scrap to the industrial salvage committee set up by the War Production Board in your community.

10) Enforce monthly re-checks in every department to find scrap material previously overlooked.

ferent metals, rubber, twine, etc., will save time sorting the material.

Collection—Scrap is of use to the war effort in direct proportion to the speed with which it is gotten back into production. Arrange regular daily or bi-weekly schedules for the various departments and sources of supply. The salvage manager should see to it that collections are turned in on time to a central collection depot in the plant. Select a definite date each week for shipment to a junk dealer or have the salvage shipped by the company to the nearest collection point.

Remember that scrap bears no label. It is old jigs, dies, castings; or it is a 10 ton machine that can't be used. Waste metal, rubber, burlap, and other critical materials are valuable even in small amounts. Every pound of these materials can be salvaged by industry.

House Cleaning—Treat the factory to a house cleaning. What was junk six months ago has its place in the war effort now. Sort rubbish carefully. Salvage what can be used, and burn or otherwise dispose of the real rubbish that cannot. Keep the premises clear of debris. This is the only method by which it can be made certain that there is nothing further to be salvaged.

Conservation—Every bit as important as salvaging vital materials is the need to conserve what we have. Use less by making better use of what we have. Get this message across to the workers. It will benefit our sons and relatives in the armed forces. By preventing spoilage and breakage, the material we work with can be turned against the enemy.

Reports—In order to coordinate the salvage campaign in the individual plant with the national effort, it is essential that regular reports on the amounts collected, according to classification, be delivered to the industrial salvage committee set up by the WPB in your community.

Above all, make clear to all personnel that until the day when we have actually turned out all the war equipment we need to smash the axis, salvage and conservation are going to remain vital phases of our production. Unless our scrap is turned into weapons *now*, America will be fighting the war with one hand tied behind its back.

"OPEN FOR DISCUSSION"
Communications to the Editor

FUEL CONSERVATION A WARTIME "MUST"

THE EDITOR— (9-4-42)

It was a pleasure to read Mr. Tyler's well-written and informative article on fuel conservation in the September HPAC; we think it will be salutary in persuading its readers to increase the efficiency of their burners and to insulate their buildings properly for the coming winter.

As you have doubtless seen in the papers, we have been asked to prepare a coupon rationing system for fuel oil intended to provide an equitable distribution of it for the coming heating season. It is probably one of the most difficult rationing programs yet attempted because of the serious hazard to individual comfort. We cannot say as yet what the maximum fuel allowance may be for we do not have all of the figures of estimated supplies as yet. However, Mr. Tyler's statement under the heading of "Just Suppose" is excellent for illustrative purposes.

We appreciate any efforts on the part of your magazine to stimulate conversion or insulation in order to help us meet the situation.—JOEL DEAN, director, fuel rationing division, Office of Price Administration.

THE EDITOR—

I just received my copy of the September issue of HEATING, PIPING & AIR CONDITIONING. I have read and re-read several times the article by Eph. A. Tyler. The article certainly shows that he knows what he is talking about.

I am wondering whether it would be possible to get about 35 or 40 copies of this article, the idea being that I send it to our larger customers who are purchasing steam from Ohio Edison Co. About all they would have to do would be to substitute the words "purchased steam" in place of "boiler plant" and the same recommendations would apply.

I would appreciate it very much if you would pass on to Mr. Tyler the comments made in this letter.—P. A. HYDE, superintendent of steam sales, Ohio Edison Co.

Old galoshes and garden hose in the form of finished slabs of reclaimed rubber are taken from the conveyor line at a plant of the U. S. Rubber Co., after being dusted with talc to prevent their sticking together and piled for storage or shipment

PRACTICAL PIPING PROBLEMS

W. H. Wilson Stresses Vigilance as Way to Achieve Efficient Operation

SUMMARY—**It's the hidden leak in a piping system that's the more wasteful, says Mr. Wilson, member of HPAC's board of consulting & contributing editors, in these brief remarks on keeping costs down. . . . He cites some incidents from his extensive experience with industrial plant piping services.**

WASTE, LOST motion, and expense are important problems which everyone must consider; those in charge of pipe lines, piping connections, valves, and piping equipment are no exception.

Piping presents operating loss problems which are different from other kinds. Some of the bad leaks and steady losses are not visible and, without inspection and attention, continually increase the cost of operation.

Invisible Leaks

I recall a remark by a man in charge of an extensive and important piping system: "When a large pipe line, overhead and in plain sight, starts leaking I usually hear about it in a very short time. The poorest workman I have can temporarily take care of the situation in some way and stop the loss. What I am more interested in is information regarding the leaks and needed repairs that you don't ordinarily see, such as steam traps leaking through the valve seat and disc (blowing through), bypass valves leaking, and leaks in out of the way places, such as tunnels, basements, and underground pipe lines. Usually the losses are of greater proportions than ordinarily supposed."

The bypass valve is useful in many ways and yet often is the cause of trouble and wasteful operation. For example, the steam traps available today are more reliable and less frequently out of order than those of other days, yet there are times when any trap may fail to operate. This situation can be taken care of by placing a valve with an outlet to the atmosphere ahead of the shutoff valve for the inlet pipe to the steam trap. The discharge end of this valve can be piped a short distance away, the open end being visible, or can discharge into a funnel with piping to a drain line. In case the trap should get out of order, this valve can be adjusted manually to allow water of condensation accumulating in the trap line to be relieved until the trap can be put in proper working order.

Steam Traps

Several steam traps of the tilting type were situated some distance from the floor in a woodworking shop, a small shelf being the support for each trap. The high pressure steam main and other units drained were overhead. The woodworking machinery, belt driven from a line shaft, made plenty of noise. Placing a ladder in position to inspect each trap and to shut off the valves required time and patience when the shop was in operation, the result being that usually when the maintenance man passed through the building, saw the traps were in their regular position, and heard no complaints about the operation of the steam equipment, he assumed them to be working in good order. This continued until one day the maintenance man was detained in another section of the plant. Coming to the woodworking shop after regular hours when the machinery was not in service, the noise from the steam traps and piping caused him to take notice and get a ladder and investigate. Some of the leaks were in the seats and discs of the traps. The bypass valves on the piping connections of the traps were leaking badly. The trap discharge line was connected to the boiler feedwater heater, situated in the boiler house nearby. The feedwater heater had a vent pipe to the atmosphere; the steam escaping to the atmosphere was considered a necessary evil.

One way of locating waste is to observe the manholes for the sewers and underground drain lines near the steam generating units and equipment using steam. All of the steam escaping from drain lines contains heat units. A case was found recently where the steam was coming from the small opening in a manhole cover near the boiler house. A careful check was made of the boiler blowoff valves and no indication of leakage was observed. Further inspection revealed that a ¾ in. pipe connection, a blowdown from the body casting of a boiler feedwater regulator, was left wide open. This blowdown was piped to the boiler blowoff main line some distance away from the boilers. Following good practice, drains of this kind should discharge into an open funnel visible from the drain valve.

Thermostatic traps are not to be forgotten. When these traps are out of order and passing steam it frequently causes trouble in other sections of the return line system. Thermometers in different sections of the return pipe lines are a help. A maintenance man can usually tell by feeling the bare pipe whether his traps are passing steam to the return pipes on a low pressure steam system. Having an accurate vacuum gage at the far ends of the vacuum return lines of the system serving scattered buildings (as for example, an industrial plant) is a help and guide in locating leakage.

If the branch lines of the heating returns are equipped with valves, it is a help to locate the pipe line that is leaking by alternately opening and closing the valves. If not equipped with valves on the branch lines, sometimes a flanged joint can be separated and a blind disc put in to temporarily close the line. If the branch lines have no valves or flanged joints a good maintenance man will not give up trying to find leaks. He will find some other way to prevent air from the atmosphere getting into his heating return pipe lines and traps passing steam. He will also see that his vacuum pump is in proper working order and by that time, if the steam supply is adequate, he will have his heating units *hot*.

BOILER FIREBOX MAINTENANCE

Kalman Steiner Discusses Boiler Refractories and the Importance of Their Proper Use Under Wartime Conditions in Plants and in Buildings

GOOD MANAGEMENT even in normal times calls for proper maintenance of boiler refractories for two obvious reasons—first, these materials are expensive and should therefore receive the attention that will increase the span of their usefulness, and second, failure of any part of the firebox during the winter may result in a boiler shutdown and interruption of building heating.

During wartime, additional considerations arise. Many plants are operating on a 24 hr schedule and are carrying heavy overloads. Refractories are therefore put to more severe duty. There is also the possibility that a few changes in design or construction of a combustion chamber may accomplish important fuel savings.

Any operating engineer responsible for maintenance of boiler fireboxes will find it very helpful to make a brief study of two technical aspects of refractories. The first is the nature of refractory materials, their chemical and physical properties, and principal applications. The second is the behavior of these materials under service conditions, the chief causes of failure, and the means by which maximum utility can be derived from refractories.

In general, refractories are made from fireclays. Essentially, fireclays are composed of silica (silicon dioxide, SiO_2) and alumina (aluminum oxide, Al_2O_3), in varying proportions, together with small amounts of impurities. In their natural state, fireclays are combinations of silica, alumina, and water. Silica occurs naturally in almost pure form as quartz, which is about 98 per cent pure silicon dioxide, and is known in industry as ganister. Pure alumina occurs naturally as corundum. Certain earths formed from the skeletons of microscopic organisms called diatoms are known commercially by various names, such as infusorial or diatomaceous earth and kieselguhr; these are composed of about 95 per cent silica and 5 per cent alumina. When a clay contains over 56 per cent alumina, such as bauxite, it is generally considered to be an aluminum ore. For the most part, firebrick are made from purified fire clay known as kaolin, represented by the chemical formula $Al_2O_3.2SiO_2.2H_2O$.

SUMMARY—Good management calls for proper maintenance of boiler refractories in normal times; in wartime, with plants operating on heavy schedules and carrying overloads, refractories are put to even more severe use, and the problem becomes more important. There is also the possibility that a few changes in the design or construction of a combustion chamber may result in worthwhile fuel savings. . . . Mr. Steiner, a member of HPAC's board of consulting & contributing editors, presents information on the nature of refractory materials, their properties, and principal applications. A second article will go further into their behavior under service conditions, chief causes of failure, and the means by which their maximum utility may be derived

Firebrick Types

The manufacture of firebrick is necessarily a complicated procedure. In brief, there are three distinct methods, known as the hand made, stiff mud or steam press, and dry press or power press methods; from each there results a brick of characteristic properties, but in any one process the product is affected by many factors, including types and proportions of raw clays mixed in the batch, the degree of fineness to which the clay is ground or the relative proportions of different grain sizes, the amount of water, the pressure exerted during molding, and the temperature and time of exposure in the kiln. Obviously, therefore, it is possible to vary the characteristics of a given grade or type of brick within fairly wide limits. The term "texture" refers principally to the visual appearance of a fractured specimen, and indicates the relative porosity—size and spacing of grains—which may vary from dense to open. The hand made process is now confined almost entirely to fire tile, which are large firebrick shapes. Most high heat duty (first quality) and superduty firebrick are made by the dry press.

From the viewpoint of their utility, the properties of firebrick are described as: refractoriness or ability to withstand high temperature; density; ability to withstand pressure or load when hot; resistance to thermal shock; constancy of volume at high temperature; inertness or chemical inactivity when exposed to slags and gases; resistance to disintegration; and thermal conductivity. The properties of a firebrick when cold are of little interest, so all testing must be conducted with brick at elevated temperatures. Refractoriness is not determined by melting point, but by comparison of softening temperature against the softening temperature of standard ceramic bodies called pyrometric cones. But even the softening temperature is not an adequate index of a brick's behavior in a firebox, for when carrying load or resisting a pressure a brick will fail at a temperature considerably below the softening temperature without load. Or again, a brick may give excellent performance at high temperature and under pressure when in a chemically neutral or inert environment, but the action of certain substances such as fused coal ash or sulphur dioxide formed in combustion may greatly shorten the useful life of the brick.

The various ranks or grades of fireclay brick, based on the performance under service conditions, are low heat duty, moderate, high, and superduty. These cover the range of alumina content between 30 and 40 per cent. When the alumina content is higher, the firebrick is usually known as a high alumina brick,

and the classification is based on the percentage of alumina.

The manufacture of superduty firebrick results from comparatively recent developments and research. Chief among the advantages of this class are excellent resistance to spalling (cracking), high density, exceptional strength, and low coefficient of thermal expansion. These brick contain about 10 per cent more alumina than standard high heat duty brick, and the softening temperature averages 75 to 100 deg higher. It is probable that this class will come into more extensive use in boiler settings as its value becomes more generally appreciated.

Plastic Firebrick

Another recently developed product is the plastic firebrick or ramming mixture. This is an unburned refractory material consisting of ground fireclay grog, raw fireclay, and water. Grog is a calcined nonplastic clay which gives the mixture volume constancy at high temperature. This mixture is frequently used instead of firebrick, sometimes for complete walls or settings, or for special portions of a setting where it can be rammed into odd or unusual shapes, as around tuyeres or burner port holes. Its use avoids the need for laborious cutting of brick.

Plastic is especially useful for repairing burned portions of a firebox. There are two grades, corresponding to high heat duty and superduty firebrick. It is important that plastic be used only where it will be subjected to sufficient temperature to assure vitrification. Unless the material is heated to high temperature it does not assume a fixed or permanent form, and will gradually deform. Nor should plastic be expected to carry load. It follows that plastic should not be used in massive thickness, since heat will not penetrate deep enough to assure complete vitrification if the wall thickness exceeds 9 in. Conversely, if applied in thicknesses less than 2 in. it is not likely to have strength enough to hold together. Arches or inclined surfaces should be reinforced with steel rods.

Properly applied, plastic makes an excellent repair material in sidewalls, bridgewalls, arches, and around port holes. When so used, a number of precautions should be observed. The burned material should be carefully and completely removed, to expose a clean brick section against which the plastic may be pounded. Plastic will not adhere to brick surface contaminated with carbon, oil, ashes, or glass-like fused refractory. It should be applied in layers of about 6 in. at a time and pounded with a 5 lb steel hammer into a uniform and smooth texture. It is well to have the boundaries between brick and plastic cut to an angle so that the plastic will hook behind the solid brickwork and gain support from it. Large amounts of it should be punctured with small holes and then heated slowly to permit escape of steam without disrupting the shape into which it has been molded in place.

Bonding Cements

There are two general classes of bonding cements for laying firebrick, known as hot setting and air setting. Hot setting cement is shipped dry and must be mixed with water to form a mortar. Fire cements are seldom applied with a trowel. The best practice is to dip each brick into the cement before laying. Hot setting cements do not form a bond until heated to vitrification, which occurs at about 1300 F. This means that they should not be used for bonding the cooler portions of a furnace structure. Some engineers have the mistaken notion that because dry cement is cheaper than air setting cement it should be used for bonding second grade brick in outer walls and backing up courses. But since high temperature is essential to the maturing of such bonds, the practice is illogical. An air setting cement is used wherever the prevailing temperature will be too low to vitrify a dry cement. This confusion possibly results from that fact that the trade often refers to air setting cements as high temperature cements. Good hot setting cement will serve as well as air setting cement at high temperatures, but requires a bit more work in preparing it for use. On the average, 250 lb of dry cement will lay 1000 brick.

Air setting cement, as the name implies, will form a bond quickly after application without vitrification. It is generally sold as a wet mix in steel containers, and for use is thinned by addition of more water until it attains a consistency that will float a firebrick with its top just above the surface. The brick should be laid by being individually dipped into the cement and then set in place, after which each brick should be tamped down and against adjoining brick with a mason's hammer. After a wall is built it is excellent practice to paint the surface with air setting cement. A good air setting cement is made of material so finely ground that it remains in suspension when mixed with water. If heavy particles settle out, the mix does not remain uniform. As shipped, 400 lb of air setting cement will usually be needed per 1000 brick.

Insulating Brick

One of the most interesting developments in recent refractory practice is the wide variety of insulating brick that has been made available. There has been for many years a considerable use of insulators made from diatomaceous earth, but these are not suited to direct exposure to fire nor even for shielded regions if there is wide or abrupt temperature change. Such insulators still are used, but the recent trend is toward more extensive employment of light density fireclay brick. Selected fireclays are molded into standard brick shapes, but organic substances are included in the mix. Upon being heated in the kiln, the organic matter is decomposed, leaving a very porous structure in the brick and thereby giving it a low coefficient of conductivity.

These insulating refractory brick are made in a number of grades, the grade generally being identified by the temperature at which it is designed for use, as 2000 deg brick, 2300 deg brick, etc. In addition to having three to four times the insulating qualities of regular firebrick, the specific heat is low, and so insulating brick heat up toward the flame temperature very quickly, a factor of importance in intermittent firing. Under equivalent conditions the life of an insulating brick is shorter than that of the standard firebrick, and so the most frequent

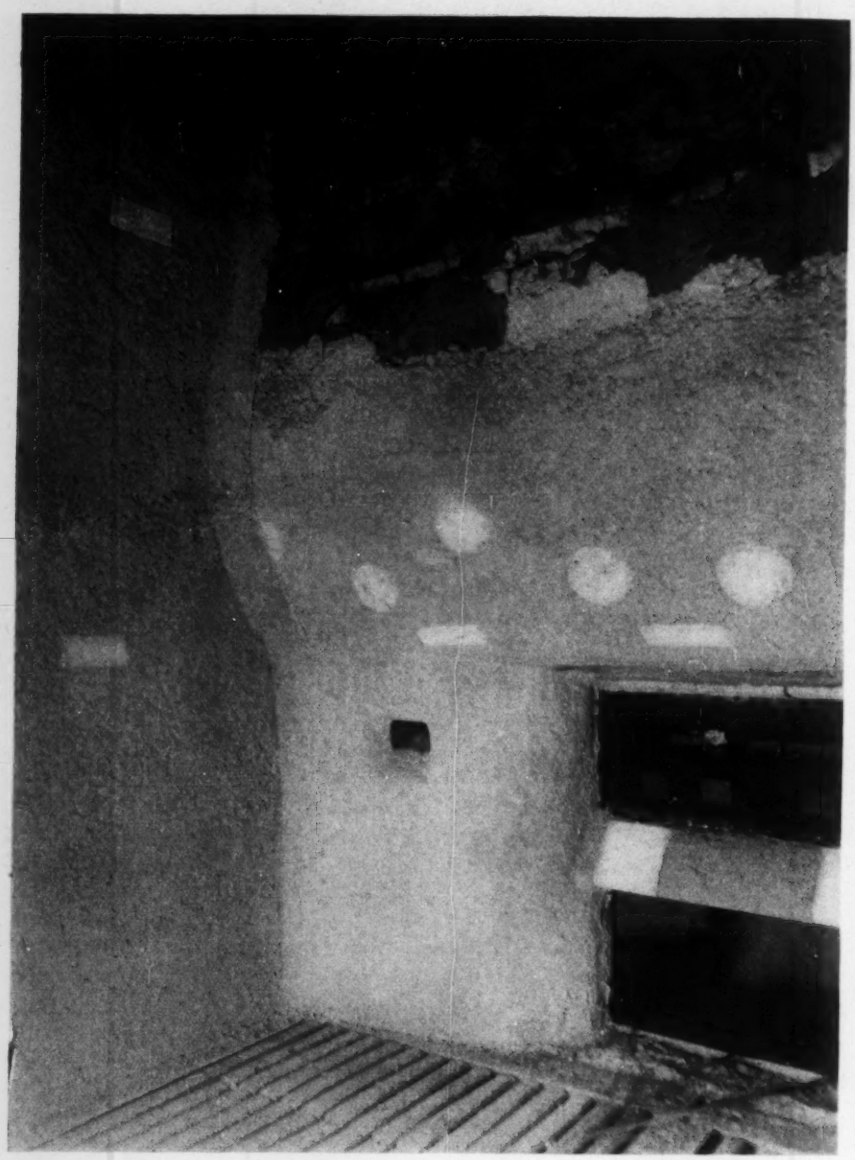


Photo courtesy A. P. Green Fire Brick Co.

A spreader type stoker setting. Portions of the front wall and suspended arch were reconstructed with plastic firebrick and extensive repairs were made to the sidewall with plastic

use is in protected positions, where standard firebrick take the brunt of the flame temperature and the insulator reduces the heat flow in a backing course. These brick should not be placed where they will come in contact with hot ashes, as a slagging action occurs very quickly. A coating of high temperature cement over the surface of insulating firebrick is very desirable.

Insulating concrete is one of a class of recently developed refractory concretes. Ordinary portland cement is made from a calcium silicate base and concretes made from it have no refractory properties. A new cement made from calcium aluminate can be mixed with suitable aggregates to form refractory concretes. The aggregates themselves are grogs made of various refractory materials, such as crushed firebrick or insulating firebrick or expanded vermiculite. The refractory concrete is prepared and poured into forms in much the same manner as standard concrete. After setting 24 hr, the refractory concrete has about the same strength as if made from portland, but it will stand up against temperatures from 2000 to 2750 F, depending upon the aggregates selected.

RESTRICTS NEW USES OF MANUFACTURED GAS

Delivery of manufactured (artificial) gas to new industrial and domestic consumers was restricted by the War Production Board in an order (L-174) designed to cope with gas shortages expected this winter. The oil shortage is having substantial effects on demands for manufactured gas, according to the WPB.

The order is a companion to order L-31, affecting natural and mixed gas, which was issued last winter.

After September 1, 1942, no gas may be delivered to a non-residential consumer for the operation of any gas fired equipment which was not operated either by the consumer or on the same premises prior to that date, unless (a) the capacity of the new equipment is less than 150 cu ft per hr, or (b) the new equipment replaces existing gas fuel equipment of the same or greater capacity, or (c) the director general for operations of WPB grants approval for the delivery of gas for the new equipment.

After September 1 no gas may be delivered for space heating (such as heating a home, store, office, or factory) unless:

1) The equipment was installed prior to September 1. If the equipment was converted from some other fuel to gas, the conversion must have been completed by September 1.

2) The equipment replaces gas fuel equipment of the same or greater capacity.

3) In the case of a new building, deliveries may be made to gas equipment installed prior to November 15, 1942, provided such gas equipment was specified in the construction contract and the foundation of the structure was completed prior to September 1, 1942.

Any person who thinks that the curtailment or prohibition of gas deliveries provided by the order will interfere with war production or essential civilian services may apply for relief to WPB. All communications should be addressed to the power branch, War Production Board, Washington, D. C., Ref. L-174.

War producers and essential civilian services listed in an exhibit to the order include hospitals, fire and police stations, post offices, court houses, schools, prisons, public eating establishments, including restaurants, cafes, bakeries, dairies, and a long list of plants exclusively engaged in war production.

FUNCTIONAL USES OF AIR CONDITIONING AND REFRIGERATION AS RELATED TO THE WAR EFFORT

General—Refrigeration may be defined as the controlled removal of heat, and air conditioning as the supplying and maintaining, in a room or other enclosure, of an atmosphere having a composition, temperature, humidity, and motion which will produce a desired effect upon the occupants of the room or upon materials stored or processed in it.

Some of the functional uses of refrigeration and air conditioning as related to the war effort are as follows:

1) *Industrial Raw Materials*

a) In the storage and preservation of raw materials which would be adversely affected by changes in temperature or humidity, or both.

b) In the treatment and preparation of raw materials prior to being utilized in war industries.

c) In processing and purifying raw materials, such as gases, chemicals, and acids.

2) *Industrial Manufacturing*

a) In precision manufacturing spaces, control of temperature, humidity, and air cleanliness, to insure uniformly high quality of product.

b) In precision assembly spaces, control of temperature, humidity, and air cleanliness, to accelerate precision assemblies.

c) In the production of interchangeable precision parts, control of temperature, humidity, and air cleanliness, to maintain uniformity of product, even under adverse weather conditions.

d) In inspection and testing of finished parts and products, to maintain uniform inspection and testing conditions to insure uniformity of product.

e) In conserving critical raw materials, machine tool capacity, and skilled manpower in the production of parts and assemblies from scarce materials. Rejects and spoilage are minimized through the control of temperature, humidity, and air cleanliness.

f) In design and layout departments of manufacturers engaged in the production of war materials, control of temperature and humidity, to maintain highest rate of production under adverse weather conditions.

3) *Storage of War Materials*

a) In the storage of certain war materials, maintaining proper temperatures and humidities, to minimize changes in volume, weight, and shape; to minimize chemical reactions; to minimize color changes; and to minimize structural distortions.

b) In the storage of vital metals, instruments, tools, and dies, control of temperature, humidity, and air cleanliness, to prevent corrosion and deterioration.

c) In the storage of precision machinery, motors, and parts awaiting assembly or shipment, control of temperature, humidity, and air cleanliness, to prevent corrosion and deterioration.

4) *Research and Development*

a) In research and development of improved war materials, to simulate unusual atmospheric conditions

to be encountered by the armed services in all parts of the world.

b) In tests of materials and equipment, to simulate atmospheric conditions of combat service to be encountered by the armed forces.

c) In developing new and better methods of manufacture of war materials, to provide optimum temperatures and humidities.

5) *Foodstuffs—Medicines—Health*

a) In the processing of food, to precool and quick freeze prior to shipment.

b) In the preservation and storage of foodstuffs, warehoused at docks, terminals, and transit points.

c) In the transportation of foodstuffs, to prevent deterioration and spoilage, through refrigeration installed on trucks, railway cars, and ships.

d) In the distribution of foodstuffs, to prevent deterioration and spoilage, through refrigeration installed in barracks, camps, depots, and those new or enlarged industrial centers caused by concentrations of manpower working in war factories.

e) In the production and storage of perishable medicines and antitoxins, to provide optimum temperatures, humidities, and air cleanliness.

f) In the production and storage of blood plasma, to provide optimum temperatures, humidities, and air cleanliness.

6) *Operations*

a) In the manufacture and assembly of telephone, radio, and other communication equipment and controls, to accelerate production through control of temperature, humidity, and air cleanliness.

b) In control rooms and other spaces where delicate and sensitive apparatus used in communications are in continual operation, control of temperature, humidity, and air cleanliness, to prevent deterioration of apparatus.

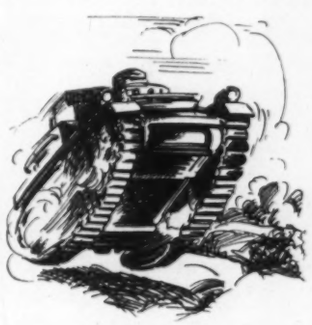
c) In spaces where equipment used in communications is in continual operation and generates considerable heat, to remove heat so generated and otherwise maintain optimum conditions of temperature and humidity.

d) In monitor or isolated stations where automatic equipment used in communications is in operation without attendants, maintenance of optimum conditions of temperature and humidity, to minimize necessity for equipment adjustments.

e) In the production and storage of maps and tracings on thin paper and blueprints, photostats, photographs, and special paper used in printing and lithographing, temperature and humidity control, to prevent distortion.

7) *Special Locations*

a) In underground stations, detection headquarters, air raid shelters, underground manufacturing plants, blackout plants, and many other strategically located, totally enclosed structures or underground spaces,



control of temperature, humidity, and air cleanliness, to provide optimum conditions for occupants of such spaces.

Partial List of Industrial Uses

Aircraft, Engines, Propellers, Instruments, Etc.:

1) To refrigerate tips of spot welding machines in aluminum welding.

2) To minimize corrosion resistance in electrolytic treatment.

3) To prevent dust and grit from spoiling the fine finish necessary on aircraft engine parts.

4) To prevent corrosion of metal parts.

5) To avoid tarnishing and rusting of metal parts, by preventing perspiration on employees' hands.

6) To maintain uniform temperatures, permitting high precision machining and uniform tolerances.

7) To hold aluminum rivets at low temperatures to preserve ductility before use.

8) To decrease scrap loss caused by dimensional variations and by scratches on highly polished surfaces.

9) To cool interior of aircraft to permit installation of instruments under adverse conditions.

10) To eliminate deleterious effects of humidity and temperature variations in paint and dope rooms.

11) To maintain uniform temperature for close measurements in inspection rooms.

12) To maintain prescribed conditions in testing rooms and laboratories.

13) To duplicate stratosphere conditions for the testing of heated flying suits.

14) To simulate severe conditions under which to test engines, instruments, accessories, and personnel.

15) To prevent a serious loss in production capacity and a waste of highly trained workers in those departments, particularly in blackout plants, where standards of high production require concentrations of lights, power, and people so great that the resulting heat load cannot be dissipated by ventilation alone.

16) To increase efficiency, speed up production, conserve skilled manpower, and increase accuracy of drawings in drafting rooms.

Automotive Combat Vehicles, Tanks, Trucks and Parts:

1) In inspection rooms, gage rooms, tool rooms, instrument assembly rooms, and other spaces where the production rate or the precision process is similar to those mentioned under aircraft and machine tool industries, to provide temperature, humidity, and dust control.

2) In drafting rooms to increase efficiency, speed up production, conserve skilled manpower, and increase accuracy of drawings.

This material was assembled by the Air Conditioning & Refrigerating Machinery Association and appears here through the courtesy of that organization.

3) In mechanical and chemical laboratories, to simulate extreme operating conditions for testing operation of equipment.

Chemicals and Plastics:

1) To prevent deterioration of chemicals in storage.

2) To control chemical processes as required for end product.

3) To control quality and purity in the manufacture of chemicals.

4) To control conditions for proper charging and storage of ammonia and other chemicals in storage tanks.

5) To process and purify anhydrous ammonia, chlorine, and other chemicals.

6) To remove heat of reaction in nitrate, methanol, and other chemical solutions.

7) To prevent deformation or spoilage during setting and hardening period.

Communications:

1) To control temperature and humidity as may be required by the particular process necessary for the manufacture of coils, wiring, radio tubes, and other products used in communications.

2) To control temperature and humidity in recording stations, broadcasting stations, apparatus rooms, and isolated automatic stations.

Drugs and Pharmaceuticals:

1) To provide uniformity of manufactured products, to control chemical reactions, to hold the proper moisture content, to inhibit bacteria growth, to prepare blood plasma, and to effect similar objectives.

2) To preserve chemicals and to prevent deterioration and reactions.

3) To control atmospheric conditions for research and testing.

4) To provide temperature and humidity control for blood banks.

Electrical Products:

1) To perform such functions similar to those outlined under aircraft and metal working industries as may be required in the manufacture, testing, and assembly of fine parts and products.

Foods, Foodstuffs, and Dairy Products:

1) To precool product before processing or transporting.

2) To freeze during processing.

3) To maintain proper conditions for preservation prior to processing.

4) To maintain proper conditions for preservation during processing.

5) To maintain proper conditions for preservation in storage after processing.

6) To maintain proper conditions for preservation during transportation.

7) To maintain proper conditions for preservation during process of distribution, including distributing warehouses, wholesale and retail stores, locker plants, food service establishments, etc.

8) To manufacture ice, which in turn serves to provide refrigeration as may be required above.

9) To preserve ice, which in turn serves to provide refrigeration as may be required above.

Iron, Steel, and Coke:

1) To control the amount of moisture in air in blast furnaces manufacturing pig iron, resulting in reduced fuel consumption, increased output, more uniform production, and better control of silicon content.

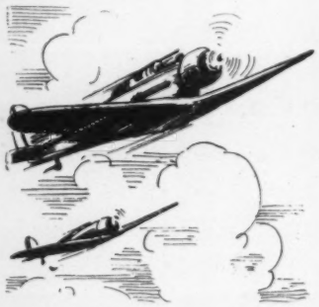
2) To control temperature and humidity to eliminate oxidation, thereby insuring bright tempering of steel.

3) To provide refrigeration necessary for the benzol freezing process, which is used to obtain special physical properties of steel.

4) To provide temperature and humidity control in powder metallurgy.

Laboratories:

1) To determine the effects of temperature and humidity on the properties of materials in industrial testing.



2) To simulate conditions required for the proper testing of materials and equipment in research and development laboratories.

3) To provide temperature and humidity control in public health laboratories for testing food, drugs, bacteria content, and human and animal diseases.

Machine Tools and Metal Working:

1) To provide temperature, humidity, and dust control to prevent spoiling fine finish of machine tools, ball bearings, gages, and other precision machinery.

2) To provide temperature and humidity control to prevent the tarnishing and rusting of metal parts as a result of perspiration on employees' hands.

3) To provide temperature control in precision manufacturing to obtain uniform tolerances.

4) To provide refrigeration required for cooling of certain lubricants.

5) To provide refrigeration required for cooling parts for shrink fits.

6) To provide temperature and humidity control in gage rooms, tool rooms, and inspection rooms.

7) To provide temperature and humidity control in drafting rooms to increase production, conserve skilled manpower, and increase accuracy of drawings and of products manufactured therefrom.

8) To provide temperature and humidity control in the manufacture of abrasive products to insure greater uniformity.

Opticals, Range Finders, Telescopes, Bomb and Gun Sights, Etc.:

1) To provide temperature and humidity control to prevent the abrasive powders used in lens grinding from becoming ineffective due to their hygroscopic nature.

2) To provide temperature control in lens grinding to prevent variations in dimensions.

3) To provide temperature, humidity, and dust control in the manufacture and assembly of precision instruments to insure uniform conditions for precision manufacture, to prevent corrosion, and to prevent dust inclusions in assembling.

4) To provide temperature and humidity control in testing rooms to permit calibration and tests under actual combat conditions.

Petroleum Processing and Refining:

1) To provide refrigeration to produce stabilization.

2) To provide refrigeration for dewaxing and de-asphalting.

3) To provide refrigeration for refining light products.

4) To provide refrigeration for increasing recovery of volatile products.

5) To provide refrigeration for decreasing requirements of circulated absorption oil.

6) To provide refrigeration for cooling low temperature distillates to purify and reduce losses.

7) To liquefy natural gas for storage.

8) To provide refrigeration for testing finished products in testing laboratories.

9) To provide refrigeration and humidity control in development laboratories for the development of petroleum products for unusual applications.

Photographic Plate, Films, and Paper:

1) To provide temperature and humidity control for maintaining flat, pliable film.

2) To provide temperature and humidity control to prevent fogging and streaking of film.

3) To provide dust free air.

4) To provide refrigeration for controlling reactions in solutions.

5) To provide temperature control of developing chemicals and fixing baths.

6) To provide temperature and humidity control for preserving, in storage, valuable negative films.

Powders and Explosives:

1) To provide temperature and humidity control to fix the rate of burning of powder.

2) To provide temperature and humidity control to permit accurate weighing of charges.

3) To provide temperature and humidity control to insure uniform moisture regain.

4) To provide temperature and humidity control to insure proper flow of powder.

5) To provide temperature and humidity control for drying smokeless powder and artillery primers.

6) To provide temperature and humidity control to reduce explosion hazard through control of static and humidity.

7) To provide temperature and humidity control for reclaiming solvents.

8) To provide temperature and humidity control to prevent deterioration of powder and explosives in storage.

9) To provide temperature and humidity control in blending, mixing, pressing, and storage of tetryl and tracer.

10) To provide temperature and humidity control in fuse loading rooms to assure accurate timing through uniformity of materials.

Rubber and Rubber Products (Including Synthetic Rubber):

1) To provide temperature and humidity control to shorten drying period and assure uniform drying.

2) To provide temperature and humidity control to increase tensile strength.

3) To provide temperature and humidity control to eliminate blisters.

4) To provide temperature and humidity control to insure uniform product.

5) To provide temperature and humidity control to permit rapid compounding.

6) To provide temperature and humidity control to prevent burning.

7) To provide temperature and humidity control to eliminate imperfect joints caused by condensation.

8) To provide temperature and humidity control to reduce oxidation to a minimum.

9) To provide temperature and humidity control to eliminate explosion hazard.

10) To provide refrigeration for cooling of rollers.

Use Cast Iron Pipe Flanges to Break Forged Steel "Bottleneck"

G. W. Hauck Tells Why and Where to Use Cast Iron Flanges, Gives Suggestions to Avoid Difficulties

SUMMARY—Increasing use of forged steel flanges in many kinds of piping services, plus wartime steel shortages, have created a "bottleneck" which has been apparent for some time, says Mr. Hauck, manager of engineering sales, Crane Co. He tells here how the use of cast iron flanges can help overcome the situation, explains the applications of cast iron, and gives suggestions which will avoid piping troubles

THE ADVENT and continuous use of higher pressures and temperatures in power plants and manufacturing processes, during the past decade or so, has been accompanied by a corresponding increase in the use of steel in piping materials. As a result, to serve these elevated operating conditions, steel initially, and of necessity, superseded the cast irons as a suitable metal in material specifications.

Almost concurrently, there was developed a gradual but definite preference for the use of steel instead of cast iron to take advantage of the greater strength of steel even in those services where the basic requirements of pressure or temperature did not suggest the use of the stronger metal.

In time, the increased production of steel progressively reduced its cost in those materials finding extensive use in piping systems. Ultimately, the differential in the costs of steel and cast iron became low enough to further accelerate the use of the better material of greater strength. This was particularly true of flanges.

The use of steel flanges, therefore, on the bulk of the lines comprising piping systems, has become accepted practice. The advantages of an unbreakable flange, of the same material as the pipe, appealed to users, because it eliminated failures due to the breakage of cast iron flanges in transit, in handling, or, at times, in the severer operating services. This was particularly true in the larger sizes of flanged joints. Thus, steel flanges found their way into saturated steam lines, and all sorts of low pressure services. Steel became the order of the day as the material for flanges used on most steel and wrought iron piping. The age of steel found piping keeping pace.

At one time, lap joints were available with the flanges made of a variety of metals—cast iron, semi-steel, malleable iron, cast steel, and forged or rolled steel. For the past decade, however, the production of lap joints has been confined almost exclusively to the use of steel flanges in general practice. The cast irons and malleable iron were practically abandoned as suitable metals for the flanges.

When welding came into widespread use as a method of making pipe joints, it had a marked and an important influence in giving impetus to the swing from iron to steel flanges. Steel flanges are required in accepted practice when they are to be attached to steel or wrought iron pipe by welding.

Developments in the refining and process industries found additional uses for steel flanges. They prove ideal for those pipe lines where fire hazard legislates against the use of cast iron. Certain services in these and similar industries also made the use of welded flanges desirable.

Steel Shortage

Thus we have traced and reviewed the principal factors responsible for the widespread use of steel flanges on much, if not, indeed, almost all of our piping work. This has created a "bottleneck" in steel flanges, a condition that has been apparent for some time, and seriously aggravated by unprecedented war demands that now make it acute because the steel required to make such flanges is desperately needed for other war production requirements. We just don't have enough steel for everything, and flanges do not escape the critical shortages. This means that users are faced with the dilemma of finding a way to bypass the shortage of steel flanges. The only apparent solution is to suspend the general practice of using steel flanges for all services. Instead, we must revert to our former habits of using steel only where service conditions make its use mandatory. For all other services, cast iron flanges, which are usually available, make an acceptable alternate. A consistent effort by all users to spread the available supply of steel flanges over a wider area of essential needs only, and using the alternate cast iron flanges in every possible service, will contribute materially to the war effort during the emergency when steel must be conserved.

Applications of Cast Iron

From the foregoing, it is apparent that a recommendation outlining the services where cast iron flanges are satisfactory is in order. Cast iron screwed flanges and cast iron lap joint (van stone) flanges are available for operating conditions which do not exceed 250 psi saturated steam pressure and in most cases where the service does not exceed 450 F maximum.

Cast iron screwed flanges are available in a range of sizes from 1 in. to 24 in., inclusive, in the 125 psi and 250 psi pressure classes. The screwed flanged joint, properly made, has proved its general utility and satisfactory performance within

its pressure and temperature limitations. If prefabricated piping is purchased, an added advantage can be gained by specifying the refacing of screwed flanged joints. In this process, the flange is made up tight until the end of the pipe projects slightly beyond the face of the flange. A light refacing cut is then taken across the face of the flange and the end of the pipe. This provides an excellent gasket bearing surface to the inside of the pipe because the end of the pipe is flush with the face of the flange. Refacing also produces perfect alignment of the flange face at 90 deg with the center line of the pipe.

Lap Joints

Again, lap joints (van stone) are generally available with cast iron flanges in a range of sizes from 2 in. to 24 in., inclusive, in both the 125 psi and the 250 psi pressure classes. In addition to the regular cast iron conforming to ASTM specification A 126 for class A castings, lap joint flanges are also obtainable made of higher strength cast iron conforming to ASTM specification A 126 for class B castings. This latter cast iron is also known as semi-steel. For the severer services, there is an advantage in using the stronger of these available cast irons.

Cautionary Suggestions

Thus, the use of cast iron instead of steel makes available the lap joint for many services where this type of joint with its advantages is preferred. But an important cautionary note is necessary. Care must be exercised in bolting up any lap joint equipped with a cast iron flange in order to prevent breakage. Pipe fitters are accustomed to finding all lap joints with steel flanges, and they cannot apply extremely heavy bolt loads or sledge bolts when cast iron flanges are employed.

Several additional cautions are suggested.

1) Cast iron flanges should never be used on the ends of any type of expansion pipe bend. Such flanges, as well as those on the piping adjacent to the expansion pipe bends, should always be of steel to preclude breakage.

2) Cast iron flanges are not recommended for lines handling hazardous fluids, or where fire hazard legislates against their use.

3) Do not exceed code limitations concerning pressure and temperature in using cast iron flanges.

HOW TO SAVE FUEL

TO AID WAR EFFORT

TWELVE WAYS in which industrial plants can save fuel were outlined last month in a program of wartime conservation. "Actual tests show that where these rules have been put into effect, fuel savings as high as 30 per cent have resulted," says John E. Haines, manager of the air conditioning controls division of Minneapolis-Honeywell Regulator Co.

The fuel conservation rules follow:

1) Maintain the minimum permissible temperature in each section of an industrial building; for example, the office at 68 deg, the machine room at 62, assembly room 65, and storage space 50. Remember that lower temperatures are more comfortable where manual labor is performed.

2) Maintain even temperatures in all occupied spaces and take frequent readings or recordings to be certain that these temperatures are being maintained.

3) Turn off the heat in unoccupied spaces or reduce the temperature to just above 32 deg where freezing would cause damage.

4) Disconnect unused lines and radiation.

5) Reduce temperatures at least 10 deg when space is not being used, such as at night.

6) Use ventilating fans only when absolutely necessary and reduce the amount of outside air taken in to a practical minimum.

7) Insulate all doors and windows and keep them closed except to maintain a minimum of ventilation required for the workers' comfort.

8) Remove anything which shields radiators, such as machines and cabinets, so that there will be no retarding of the flow of heat.

9) Have a competent heating engineer make a complete survey of the heating system and make any changes he recommends.

10) Employ a competent maintenance man to operate the heating system and make a complete survey of the system at least once a month.

11) Make every effort to obtain the cooperation of everyone in the building to save fuel by keeping windows and doors closed and by reporting overheating.

12) Control the temperature of hot water delivered to factory processes and washrooms at the minimum permissible.

FAN LAWS--Their Derivation and Use

Thorough Understanding of Fan Laws of Great Value to Users, Permits Selection for Efficient Operation . . . By William Goodman

SUMMARY — A thorough understanding of the fan laws can be of great value to the user of fans. The fan laws can be of help in selecting fans so that they operate at their most efficient point and in determining the effect of changes in fan speed. Important in many cases is the effect of changes in the density of the air that the fan is handling. All fans are rated in terms of standard air, the density of which is 0.075 lb per cu ft. . . . . Although the effect on fan performance with changes in air density can frequently be neglected, there are many cases where these effects should be taken into account. It has been the author's experience that the fan laws dealing with changes in density are particularly likely to be misapplied. In the article of which this is the third and concluding part, a clear explanation is given of the proper application of the fan laws and their use is illustrated with examples. . . . . Mr. Goodman is consulting engineer, the Trane Co., and a member of HPAC's board of consulting & contributing editors

Change in Horsepower with Change in Speed and Density

IF THE speed of a fan is changed in order to obtain the delivery of a given weight of air, the horsepower requirements of the fan will also change. The horsepower required to drive a fan depends upon the density of the air that the fan is handling. If the horsepower required for the fan when it is handling standard air is known, the horsepower required when its *speed is changed* to compensate for a *change in density* can be computed by means of the following equation:

$$\frac{(hp)_2}{(hp)_1} = \left(\frac{d_1}{d_2}\right)^2 \quad \text{.....[40]}$$

This equation is derived as follows: Equation 41, based on equation 20, may be written

$$\frac{(hp)_2}{(hp)_1} = \frac{V_2 p_2}{V_1 p_1} \quad \text{.....[41]}$$

Multiplying equations 35 and 36,

$$\frac{V_2 p_2}{V_1 p_1} = \left(\frac{d_1}{d_2}\right)^2 \quad \text{.....[42]}$$

Eliminating the ratio $(V_2 p_2 / V_1 p_1)$ between [41] and [42], equation 40 is obtained.

Example 7—When handling air of standard density, a fan requires 4.3 brake horsepower. Find the horsepower required when the fan is handling air whose density is 0.07184 lb per cu ft.

Solution—Using equation 40,

$$(hp)_2 = 4.3 \left(\frac{0.075}{0.07184}\right)^2$$

= 4.7 brake horsepower required for the fan when delivering air whose density is 0.07184 lb per cu ft.

Change in Pressure with Change in Density at Constant *Fan Speed*

The preceding discussions have been concerned with the change in fan performance when the fan speed is *changed* to compensate for a change in air density. However, there are many cases in which the change in performance with changes in density is of interest even though the fan speed remains *constant*. In this section and in the next one, the performance at *constant* fan speed but changing density will be discussed.

As stated previously, a fan running at constant speed and delivering air through a given duct system —that is, a fan operating at a given velocity ratio—will always deliver the same volume of air regardless of the density of the air. However, the pressure—measured in inches of water—developed by the fan will change with the density of the air. Hence, if the temperature or the barometric pressure of the air changes, the pressure indicated by a manometer will also change even though no changes take place in the duct system itself.

For a fan operating at constant tip speed and at the same point on the ratio curve of Fig. 2 [see p. 488, August, 1942, HPAC]; it is evident from equation 12 that

$$\frac{p_2}{p_1} = \frac{d_2}{d_1} \quad \text{.....[43]}$$

A fan running at constant speed must frequently handle air at different temperatures. Thus a fan installed in an air conditioning system may handle air at 100 F in winter and at 45 F in summer without any change in its speed. The pressure indicated by a manometer in both cases will be different even though no changes (such as changes in damper setting) take place in the duct system through which the air is flowing. In both cases, the pressure that will be indicated by a manometer can be computed by means of equation 43 from the pressure estimated for standard air.

Another use for equation 43 is found in fan tests. Standard air can rarely be obtained during the course of a test. Hence, if a performance curve is desired for standard air, the test results must be corrected. Equation 43 is used to determine either the static or total pressures that would have been obtained had the fan been circulating standard air during the test.

Inasmuch as, during any one test, the fan speed is constant, the volume of air delivered by the fan and consequently the outlet velocity remain constant regardless of the density of the air.

Incidentally, it is of interest to note that a ratio curve such as Fig. 2 is independent of the density of the air. The ratio curve can be computed directly from a test performance curve like the one in Fig. 1 [p. 487, August HPAC] without making any corrections for density. To do so, the actual density of the air must be used when computing the velocity pressure. The following problem illustrates the interesting fact that the ratio curves of Fig.

Symbols

d = density of air, lb per cu ft;
h = head, ft of air;
(hp) = horsepower;
p = pressure, in. of water;
p_s = static pressure, in. of water;
p_t = total pressure, in. of water;
p_u = velocity pressure, in. of water;
R_p = pressure ratio (see equation 2);
U = velocity, fpm;
U_o = outlet velocity of fan, fpm;
U_p = peripheral velocity or tip speed, fpm;
V = volume of air per unit of time, cfm;
w = mass velocity of air, lb per min per sq ft of cross-sectional area;

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2 can be used for computing the performance of a fan handling air of any density.

Example 8—Using the ratio curve of Fig. 2, on p. 488, August HPAC, compute the static pressure developed by a 30 in. fan running at 280 rpm when the density of the air handled by the fan is (a) 0.07488; (b) 0.07184. Assume that the fan is operating at the point on the ratio curve where $R_p = 0.858$. (c) Compute, by means of equation 43, the static pressure for standard air from the static pressure obtained in part (b).

Solution—(a) $U_p = \pi \times 2.5 \times 280 =$ 2199 fpm.

Referring to Fig. 2, for $R_p = 0.858$, $(U_o/U_p) = 0.587$. Hence, $U_o = 0.587 \times 2199 = 1291$ fpm. The velocity pressure can be computed by means of the following equation (see p. 572, 1941 ASHVE GUIDE):

$$p_u = d\left(\frac{U_o}{1096.5}\right)^2$$

$$p_u = 0.07488\left(\frac{1291}{1096.5}\right)^2$$

$$= 0.1038 \text{ in. of water.}$$

Inasmuch as the total pressure is equal to the sum of the static and velocity pressures, the total pressure can be eliminated from equation 2 and the static pressure can be found directly by means of the following equation*.

$$p_s = \frac{p_u}{\frac{1}{R_p} - 1}$$

$$= \frac{0.1038}{\frac{1}{0.858} - 1}$$

= 0.627 in. of water static pressure developed by the fan when handling air whose density is 0.07488 lb per cu ft.

(b)

$$p_u = 0.07184\left(\frac{1291}{1096.5}\right)^2$$

$$= 0.0996 \text{ in. of water.}$$

$$p_s = \frac{0.0996}{\frac{1}{0.858} - 1}$$

= 0.602 static pressure developed by the fan when handling air whose density is 0.07184 lb. per cu ft.

(c) If the static pressure developed by the fan when it is handling air whose density is 0.07184 is known, the static pressure that would be developed when handling standard air can also be computed by means of equation 43. Using equation 43,

$$p_2 = 0.602 \times \frac{0.075}{0.07184}$$

= 0.628 in. of water when handling standard air.

*From equation 2,

$$R_p = \frac{p_s}{p_t}$$

$$= \frac{p_s}{p_s + p_u}$$

$$= \frac{1}{1 + \frac{p_u}{p_s}}$$

Hence,

$$p_s = \frac{p_u}{\frac{1}{R_p} - 1}$$

Change in Horsepower with Change in Density at Constant Fan Speed

Equation 40 is used to determine the horsepower required when the fan speed is *changed* to compensate for a change in the density of the air so that the required weight of air will be delivered. On the other hand, if the fan speed is held *constant*, the volume of air delivered by the fan will be constant but the weight will vary with the density of the air being circulated. Under these circumstances, the horsepower required to drive the fan will also vary with the density of the air. If the horsepower required for a fan when it is handling standard air is known, the horsepower required when the density of the air is changed, but the fan speed is held *constant*, can be computed by means of the following equation.

$$\frac{(hp)_2}{(hp)_1} = \frac{d_2}{d_1} \quad \text{.....[44]}$$

This equation is derived as follows: From equation 20,

$$\frac{(hp)_2}{(hp)_1} = \frac{V_2 p_2}{V_1 p_1} \quad \text{.....[45]}$$

But for a fan at constant speed,

$$\frac{V_2}{V_1} = 1 \quad \text{.....[46]}$$

Substituting equations 43 and 46 into equation 45, equation 44 is obtained.

As stated in the previous section, a fan may handle high temperature air in winter and low temperature air in summer without a change in speed. In such a case, the horsepower required under both conditions can be determined by means of equation 44. This equation is also frequently used in fan tests to correct the horsepower obtained by actual measurement to the horsepower that would have been obtained had the fan been circulating standard air during the test.

Example 9—A fan delivering 12,200 cfm requires 2.03 brake horsepower when handling standard air. Find the power required at the same speed when the fan is handling air whose density is 0.07184.

Solution—Using equation 44,

$$(hp)_2 = 2.03 \times \frac{0.07184}{0.075}$$

$$= 1.94$$

It is important to distinguish clearly between the uses of equations 40 and 44. Equation 40 is used to determine the horsepower required when the fan speed is *changed* to compensate for a change in the density of the air so that the required weight of air will be delivered. On the other hand, equation 44 is used to determine the horsepower when the fan speed is held *constant* and consequently the volume of air circulated by the fan is also constant.

Usually the difference between the actual density of the air and that of standard air is so small that the corrections for fan speed and horsepower may be neglected. However, there are many cases, particularly in drying problems, where the change in density is sufficiently large so that these corrections should be made.

Friction Loss in Ducts

All of the charts used in computing the friction loss in ducts, such as the one on p. 574 of the 1941 ASHVE Guide, are based on standard air. Frequently, however, the actual density of the air flowing through the duct system is different from that of standard air. In such a case, the friction loss of the air flowing through the duct as measured by a manometer will be different from the friction loss that would have been obtained if standard air had been flowing through the duct.

Suppose that the friction loss for a given weight of air flowing through the duct system has been computed by means of a chart based on standard air. For the *same weight of nonstandard air* flowing through the duct system, the pres-

sure loss that will be obtained can be computed from the pressure loss for standard air by means of the following equation:

$$\frac{p_2}{p_1} = \frac{d_1}{d_2} \quad \text{.....[47]}$$

This equation is derived as follows: The fundamental formula for the friction loss through a duct or other apparatus through which air flows is

$$h = KU^2 \quad \text{.....[48]}$$

where K is a constant. This may be written

$$h = K \left(\frac{Ud}{d}\right)^2 \quad \text{.....[49]}$$

The mass velocity of the air is the weight of air flowing per square foot of cross sectional area, or

$$w = Ud \quad \text{.....[50]}$$

Hence, equation 49 reduces to

$$h = K \left(\frac{w}{d}\right)^2 \quad \text{.....[51]}$$

Eliminating h by means of equation 11 and combining all constants into one new constant, k,

$$p = k \frac{w^2}{d} \quad \text{.....[52]}$$

For a constant mass velocity or for a constant weight of air flowing through the duct system, equation 47 is obtained from equation 52.

Inasmuch as equation 47 is the same as equation 36, it is evident that the pressure loss in a duct system varies with density in the same manner as the pressure developed by a fan. If the density of the air flowing through the fan and through the duct system is the same, the pressure developed by the fan will always match the pressure loss in the duct system regardless of the density. This being the case, it is apparent that ducts can be designed on the basis of standard air and fans selected on the basis of standard air. Then by correcting the fan speed and horsepower in accordance with equations 32 and 40 respectively, the fan will automatically deliver the required weight of nonstandard air against the actual static pressure of the duct system.

Inasmuch as all fan performance curves and tables are based on standard air, fans can be selected conveniently only on the basis of standard air. Consequently, in designing ducts, a duct chart based on friction loss with standard air may be used regardless of the actual density of the air. If the computations for the duct system are based on standard air, and the fan speed and horsepower corrected by means of equations 32 and 40, the duct system will be correctly sized, the fan properly selected, and the proper weight of air delivered to the conditioned spaces.

The quantity of air that the fan will actually deliver, and the static pressure against which it will actually work after it has been installed can be computed by means of equations 35 and 36.

The discussion in the preceding paragraphs applies only when ducts are to be designed and a fan selected for a given installation. However, when testing a fan which has already been installed and which is handling nonstandard air, a different procedure must be followed. In testing a fan, the air volume is measured. As has previously been stated, if the fan speed remains constant, the volume of air handled by the fan will remain constant regardless of the density of the air being circulated by the fan. Hence, no correction need be made for the measurement of air volume. However, in order to compare test results with fan ratings based on standard air, the static pressure and the brake horsepower measured during the test must be corrected to determine the static pressure and brake horsepower that would have been obtained had the fan been handling standard air. For this purpose, equations 43 and 44 must be used.

Density of Air in Duct and Fan Differ

Occasionally installations are made in which a heating coil is installed between the fan and the ductwork. As a result of this, the air flowing through the duct is at a different temperature and has a different density than the air flowing through the fan. Evidently the weight of air flowing through the duct is exactly the same as the weight delivered by the fan. However, the volume of warm air flowing through the duct is greater than the volume of air flowing through the fan.

If the ductwork has been designed on the basis of the volume of standard air needed, the static pressure against which the fan must actually work will be different from the static pressure computed on the basis of standard air flowing in the duct. As previously shown, equation 47 is used to determine the actual friction loss in a duct through which nonstandard air is flowing. It is apparent that even though the fan may be handling standard air, the pressure against which the fan must work is actual static pressure loss in the ductwork. Hence, if nonstandard air is flowing through the duct, the actual static pressure loss as computed by means of equation 47 must be used when selecting the fan even though the fan is handling standard air. However, the actual volume of standard air to be delivered should be used for selecting the fan even though the static pressure is computed on the basis of nonstandard air. The following example illustrates this.

Example 10—A given weight of air must be delivered through a certain duct system. The static pressure loss with standard air flowing through the duct system is 0.85 in. Find the static pressure loss in the duct if the air flowing through the duct has a density of 0.068 lb per cu ft.

Solution—Using equation 47,

$$p_2 = 0.85 \times \frac{0.075}{0.068}$$

$= 0.937$ in., actual static pressure against which the fan must work.

For the conditions of the foregoing example, a fan should be selected for the volume of standard air circulated but against a static pressure of 0.937 in.—not 0.85 in. Thus, if 15,000 cfm of standard air were needed for the conditions of the foregoing example, the fan would be selected from the multirating tables in a fan catalog for 15,000 cfm of standard air against 0.937 in. of water, disregarding the static loss with standard air.

BUY MORE WAR BONDS!

Commercial, Institutional, and Industrial Buildings Must Convert to Coal if Facilities Available, Says OPA

COMPLETE DENIAL of rations of fuel oil for heating in apartment houses, and commercial, industrial, and institutional establishments which possess the facilities to convert to coal, was announced last month by Paul M. O'Leary, deputy OPA administrator in charge of rationing.

Mr. O'Leary said that a large proportion of buildings, all heavy users of fuel oil, including apartment houses, office buildings, and manufacturing plants, can be easily converted to coal. "The desperateness of the fuel oil situation demands that they do so," he said.

"The government has carefully cleared the way for conversions and arrangements have been made for priorities on materials and the manufacture of lugs, shaker bars, grates, and ashpit doors. In fact, many of these things are now made, waiting to be used.

"We are urging everyone to convert who can—domestic as well as commercial users," Mr. O'Leary added. "But we might remember that the oil saved from one large building that converts is enough to heat a score or more of homes all winter. Let's put it this way—fuel oil consumed to heat a building that might have been converted, but wasn't, will mean that a score or more of homes will be insufferably cold this winter.

"No person should be permitted to make inroads on our precious stock of fuel oil and thereby increase the discomfort of people who cannot convert. Every person who can do so at a moderate sacrifice should take his fuel oil consumption off the market entirely, and thus relieve the suffering of other people."

Mr. O'Leary said that commercial, industrial and institutional establishments will be required to report on the convertibility when they register for rations of fuel oil. Rationing boards, it was pointed out, will have the benefit of advice from heating experts in determining if such establishments should be denied rations.

In no event, whether it be a private home or a large manufacturing plant, will any establishment be eligible for a fuel oil ration if a new oil burner or equipment converting the furnace from other fuels to fuel oil has been installed since June 1, 1942.

Other types of uses for which rations will be denied regardless of their convertibility include coal spraying equipment and other users to the extent to which standby facilities that use fuels other than oil are usable. For example, some commercial establishments have coal boilers idle or in operation only part time since installation of new oil burning equipment.

Rations for large buildings that cannot convert will be set differently from those for private homes. The heat loss formula based on floor area will not be applied. Instead the ration will be a percentage of last year's consumption with adjustments made to take into consideration degree days. In most cases, the curtailment under rationing will probably be at least as great as that in private homes, which is expected to be 33⅓ per cent under last year.

Exceptions will be made for hospitals where a severe cut might present serious health hazards.

Four Zones

Wide disparities in climate throughout the 30 states in which fuel oil will be rationed will be considered in determining the rations householders will receive, the Office of Price Administration has announced. The rationed area has been divided for this purpose into four thermal, or heat, zones. In addition, numerous subzones are being established to provide for ration adjustments in localities where the climate has been found to be unusual. Wherever possible state lines have been followed in setting up the thermal zones. However, because the climate varies extensively in certain states, the zone lines cut through some states and follow county lines:

Zone A—Maine, New Hampshire, Vermont, 15 counties in northern New York, Michigan, Wisconsin, Minnesota, North Dakota, South Dakota, and northern part of Iowa.

Zone B—Massachusetts, Rhode Island, Connecticut, New York (except upper 15 counties), Pennsylvania, New Jersey, Nebraska, and parts of Ohio, Indiana, Illinois, Iowa, Kansas, and Missouri.

Zone C—Delaware, Maryland, Virginia, West Virginia, District of Columbia, Kentucky, lower parts of Ohio, Indiana, Illinois, Missouri, and Kansas.

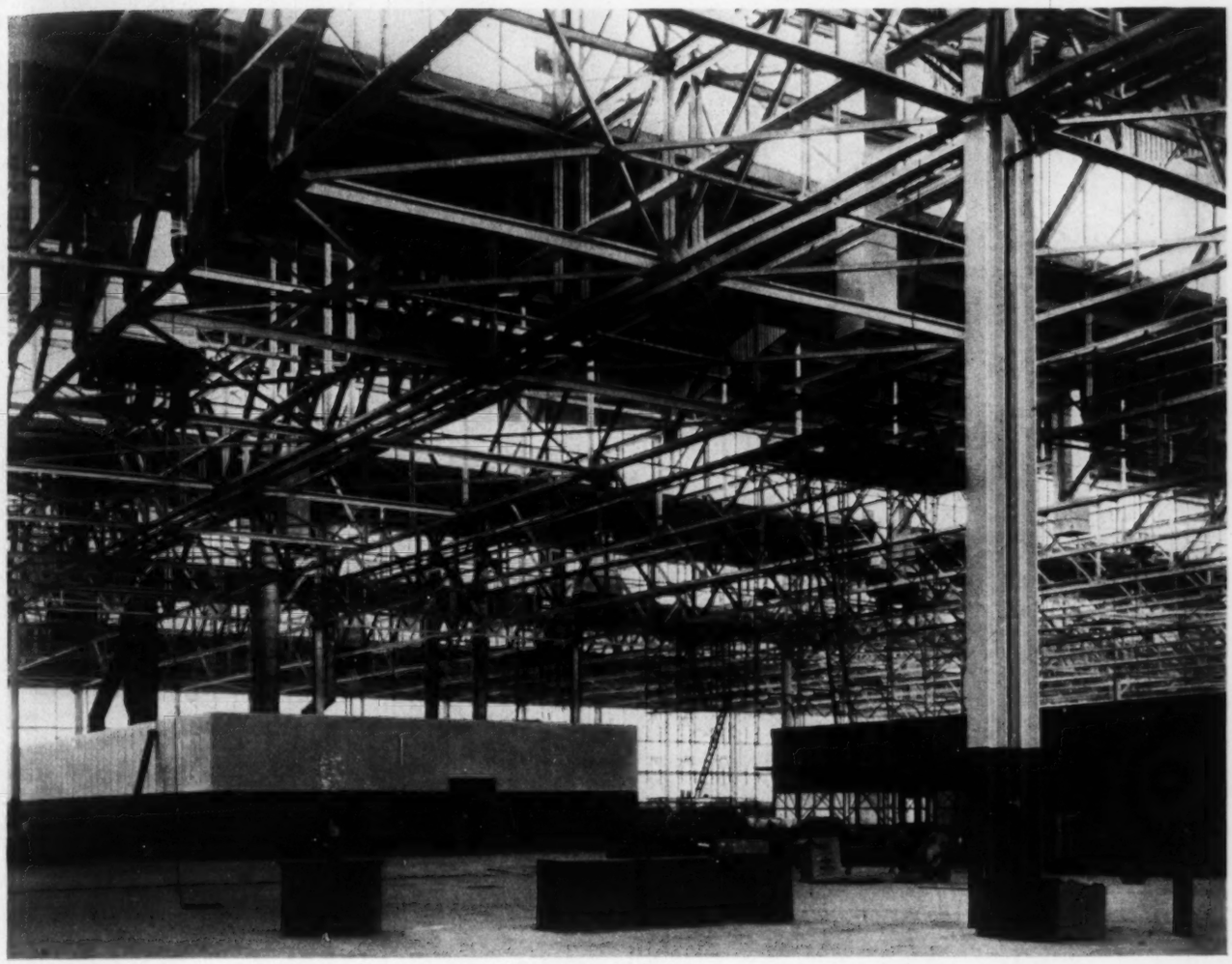
Zone D—North Carolina, South Carolina, Georgia, Florida east of the Apalachicola River.

HAROLD V. COES TO HEAD ASME

Harold V. Coes, vice-president of Ford, Bacon & Davis, Inc., was elected by a letter ballot of the 16,250 members of the American Society of Mechanical Engineers to be president of the society during 1943.

Vice-presidents elected at the same time to serve two year terms on the council of the ASME are Joseph W. Eshelman, president, Eshelman & Potter; Thomas E. Purcell, general superintendent of power stations of the Duquesne Light Co.; Guy T. Shoemaker, vice-president, Kansas City Light & Power Co.; and Walter J. Wohlenberg, professor of mechanical engineering, Yale University.

Managers of the society elected to serve on the council for three year terms include Roscoe W. Morton, professor of mechanical engineering and head of the department, University of Tennessee; Alexander R. Stevenson, Jr., staff assistant to vice-president, General Electric Co.; and Albert E. White, director of engineering research, University of Michigan.



Modern Ventilation Makes Blackout Plants Possible

F. O. Jordan Describes First Installation of Ventilating and Heating Method Now Used in Many War Production Factories

SUMMARY—War has made blackout plants essential; and because a lightproof building is also airtight, industrial ventilation design and application are more important than ever before. . . . A method of ventilation and heating which is widely used in war production plants throughout the United States is described here by Mr. Jordan, mechanical engineer with Albert Kahn Associated Architects and Engineers, Inc. It involves motor driven supply and exhaust ventilation with weatherproof and lightproof hoods in the roof, vertical projection unit heaters, and blower type unit heaters for screening doorways with high velocity air when large doors are opened

WHEN THE airplane manufacturing plant described in the following paragraphs was planned, the designers—Albert Kahn Associated Architects and Engineers, Inc.—kept before them the possibility of attack by high-flying night bombers. Blackout provisions naturally were deemed essential.

Of course, the first requirement for blackout is that the building be designed and constructed so it can be darkened—quickly and *completely*. Windows, doors, and other openings must be sealed so they are lightproof. Unfortunately, however, lightproof materials are also airtight. If ample artificial illumination is provided, men can work without the light of day, but they must have an abundant supply of outside air.

In a blackout factory, the ventilation problem is intensified in summer's heat. Modern factories are so full of workers, electrically operated machinery, and brilliant illumination that the internal heat load is terrific.

***Above*—A view taken during construction of a plant showing a winter supply unit at the upper left and discharge ducts coming down from summer supply units at the right.**

Furthermore, the beating down of the summer sun on vast roof areas adds millions of solar Btu's to the heat generated inside. Temperatures can rise above 150 F under certain conditions unless an adequate volume of outside air is supplied.

The way this outside air is supplied and the heat is removed from this particular plant can be said to have established a precedent. At any rate, the same method is now being used to improve working conditions and eliminate dips in the summer production curve in numerous war production plants across the United States.

Ventilators

The method involves the installation of motor driven supply and exhaust ventilators in the roof. These ventilators consist of weatherproof and lightproof hoods, containing vertically mounted propeller type fans. The supply units are provided with discharges extending down to the bottoms of the roof trusses so they do not disturb the tendency of heated air to stratify close under the roof. The air is discharged at a velocity sufficient to obtain convection cooling down at the occupancy level.

The exhaust units are at the high points of the roof, so they draw off the hot air as it rises to the higher levels in the building. All units are provided with automatic dampers that open only when the fan is in operation, and the hoods on the roof are hinged to make the motors accessible for servicing.

This method prevents inside temperatures from rising to points more than 10 F higher than the temperature levels prevailing outside.

Unit Heaters

Heating in the winter is provided by overhead, vertical shaft, projection unit heaters installed up in the truss space where they are out of the way. This type of unit, it has been found, will maintain a circulation of heat downward so that stratification of temperature is minimized and constant conditions of comfort are maintained in all parts of the building. Certain of the unit heaters are provided with outside air intake connections. Thus, enough outside air is brought in to maintain satisfactory air purity and replace the air removed from the interior by process exhausters.

Door Heating

One of the problems the engineer encounters in these aviation plants is that of devising methods of keeping winter gales from blowing all the heat out of the building when the hangar type doors are open. The condition is met in this plant with blower type unit heaters installed at the doorway in such a manner that they discharge vertically downward to maintain high velocity air screens across the door openings. These units are controlled by door switches and inside thermostats arranged to start the units as soon as the doors are opened, regardless of the inside temperature. After the doors are closed, they continue operating until the inside temperature has risen to the setting of the thermostats.

Other heating units are also controlled by thermostats. Ventilating systems consisting of fans, ducts, and the like have even been installed in such portions of the building as locker rooms and toilets.

Steam Supply

Steam is supplied at 175 psi pressure from the boiler house and is reduced to 30 psi for distribution to the unit heaters. Condensate is returned by gravity from the heating units to duplex condensate pump and receiver units, whence it is pumped back to the boiler house.

The factory boiler plant installation is most complete in every detail. The boilers are of the water tube variety. Diesel engine driven air compressors and a standby electric generator are important parts of the installation.

The condensate from the heating system is returned to an elevated feedwater heater, from which it is returned to the boilers by feed pumps. There are three of these pumps—one of the steam driven, reciprocating type, one a turbine driven centrifugal pump, and one a motor driven centrifugal pump. Complete controls are provided, including boiler feed regulators and combustion controls.

Process Steam

In addition to the steam required for the heating system, certain manufacturing processes also demand it. Steam is supplied for heating water and in connection with paint sprays and anodizing. The steam for manufacturing processes is supplied at 175 psi pressure.

Compressed air is provided by air compressors in the boiler house for riveters and other pneumatic tools.

Hot water requirements are taken care of by surface type water heaters supplied with steam.

LIMITATION ORDER ON INDUSTRIAL CONTROLS

WPB limitation order L-134, which restricts the use of chromium, nickel, and their alloys to specified operating conditions of instruments, valves, and regulators of the type used industrially, has been revised by the director general for operations in the interest of further conservation of critical materials.

Ratings on which manufacturers or dealers are permitted to deliver new equipment have been raised from A-10 to A-1-c, and the required rating for deliveries of repair and maintenance supplies has been changed from A-10 to A-8 or higher, except on equipment needed by the Army, Navy, Maritime Commission, War Shipping Administration and other designated agencies.

WPB'S AIR CONDITIONING BRANCH CONSOLIDATED

A recent administrative order of the War Production Board abolished the air conditioning and commercial refrigeration branch and transferred functions, personnel, records, and equipment to the general industrial equipment branch.

★ ★ ★

PUT 10% IN WAR BONDS

★ ★ ★

Heating · Piping and Air Conditioning

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

Journal Section

HEAT IN THE HEADLINES

Much space, in newspapers, magazines, trade and technical publications, is currently being devoted to Fuel Conservation, How to Heat Homes Economically, Fuel Oil Rationing, and allied subjects. The news reels have done their bit to make people realize the importance of joining the "War on Fuel Waste."

Fuel oil rationing, commencing October 15, in 30 states has been announced officially by the Office of Price Administration. Four zones have been designated as follows: Zone A—Maine, New Hampshire, Vermont, New York (15 northern counties), Michigan, Wisconsin, Minnesota, North and South Dakota, and northern Iowa. Zone B — Massachusetts, Rhode Island, Connecticut, New York (except 15 northern counties), New Jersey, Pennsylvania, Nebraska, parts of Ohio, Indiana, Illinois, Iowa, Kansas, and Missouri. Zone C—Delaware, Maryland, Virginia, West Virginia, District of Columbia, Kentucky, lower parts of Ohio, Indiana, Illinois, Missouri, and Kansas. Zone D—North and South Carolina, Georgia, Florida (east of Apalachicola river).

Before October 15, householders will be required to file applications for fuel oil with their local rationing boards. Answers to 34 questions are necessary and fuel oil allotments, in gallons, will be made according to the following formula: Square feet of living space multiplied by degree days for thermal zone divided by a constant 3750 or 5000. Ration coupons are not to be available until November 30, but oil deliveries will be made by dealers between October 1 and November 30 subject to the surrender of coupons for equivalent amounts of oil. Reductions of 33⅓ per cent from last year are expected.

Members of the Society in the rationed areas have been invited to aid the OPA in furnishing qualified personnel to advise local rationing boards on appeals for supplemental rations and on other technical questions.

As this goes to press, the complete plan is being prepared for public announcement. Watch for it in daily newspapers.

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Printed in U. S. A.

Design of Spray Cooling Ponds

By S. Hori*, U. A. Patchett** and L. M. K. Boelter†
Berkeley, Calif.

This paper is the result of research sponsored by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS in cooperation with the University of California.

SUMMARY—A method for the design of spray cooling ponds is outlined, based on the theory of energy transfer, utilizing a unit volume energy conductance. Application of the proposed method is illustrated by presenting performance curves of a typical spray pond with high and low pressure nozzles. A comparison of the drop sizes for the two types of nozzles is given.

THIS PAPER presents a design method applicable to spray cooling ponds based on the consideration of the energy transfer from the cooling water to the ambient air. The complexity of the phenomena which take place in the actual system makes necessary several idealizations, in order to present a method which can be applied readily in practice.

Nomenclature

a = surface area of drops, square feet per cubic foot of spray volume.

c = specific heat of liquid water, Btu per (pound) (degree) (Fahrenheit).

e = effectiveness.

$F(p)$ = the mean diameter of the spray for a single nozzle which is a function of the pressure at the nozzle, feet.

$F'(p)$ = height of the top of the spray above the nozzle, also a function of the pressure at the nozzle, feet.

h = enthalpy of air-water vapor mixture, Btu per pound of dry air.

h'' = enthalpy of saturated air at the water temperature, Btu per pound of dry air.

h_a = enthalpy of surrounding ambient air, Btu per pound of dry air.

K = unit volume energy conductance for the total volume of spray, Btu per (hour) (square foot) (Btu per pound).

(Ka) = unit volume energy conductance, Btu per (hour) (cubic foot) (Btu per pound).

L = water rate to the nozzles, pounds per hour.

lm = logarithmic mean.

n_x = number of rows of nozzles along the length of a symmetrical pond.

n_y = number of rows of nozzles along the width of a symmetrical pond.

p = pressure at the nozzles, pounds per square inch gage.

t = water temperature, degrees Fahrenheit.

t_w = wet-bulb temperature of ambient air, degrees Fahrenheit.

V = total volume of spray above the pond surface, cubic feet.

x = distance between nozzle rows along the length of a symmetrical spray pond, feet.

X = total length of spray, feet.

y = distance between nozzle rows along the width of a symmetrical spray pond, feet.

Y = total width of spray, feet.

z = height of nozzles above pond surface, feet.

Z = total height of spray above the pond surface, feet.

Subscripts 1 and 2 refer to the water before and after spraying, respectively.

Neglecting the amount of water lost by evaporation, entrainment, or otherwise, the over-all rate of heat loss by the water is given by:

$$L_1 c\ (t_1 - t_2) \quad \ldots\ldots (1)$$

The over-all energy transfer rate for the total spray volume may be expressed simply and with reasonable accuracy as:[1, 2]

$$(Ka)\ V\ \triangle h_{1m} \quad \ldots\ldots (2)$$

where $\triangle h_{1m}$ is the logarithmic mean driving potential and is expressed as:

$$\triangle h_{1m} = \frac{h''_1 - h''_2}{lm\epsilon \left(\frac{h''_1 - h_a}{h''_2 - h_a} \right)} \quad \ldots (3)$$

This mean driving potential can be determined readily, since the usual temperature measurements taken during tests on the spray ponds are the initial and final water temperatures and surrounding air wet-bulb and dry-bulb temperatures. This definition of the mean driving potential presumes that the enthalpy of the air throughout the spray volume is that of the surrounding ambient air. The actual air enthalpy within the spray volume, however, will always be greater than the enthalpy of the surrounding air, and thus the mean driving potential as computed on this basis will be higher than the actual.

Assuming that all of the heat lost by the water is transferred to the air, Equations (1) and (2) are equated:

$$L_1 c\ (t_1 - t_2) = (Ka)\ V\ \triangle h_{1m}$$

Transposing the terms,

$$(Ka) = \frac{L_1 c\ (t_1 - t_2)}{V\ \triangle h_{1m}} \quad \ldots\ldots (4)$$

Equation (4) defines the unit volume energy conductance (Ka) for spray cooling ponds and resembles the conductance used in the investigation of spray cooling towers.[3] The effectiveness of a given unit as an energy exchanger depends on the unit volume energy conductance (K) and the transfer area per unit spray volume (a). Since neither of these can readily be determined independently, the product of the terms is defined as

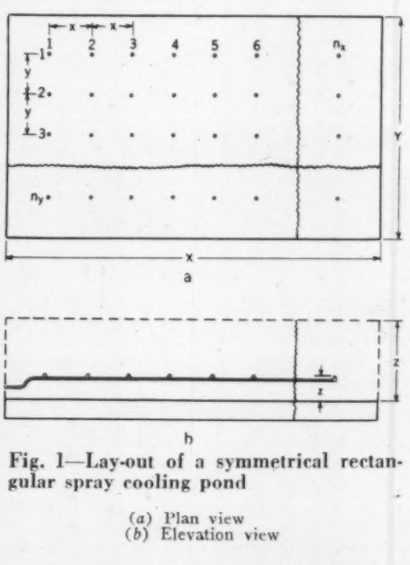

Fig. 1—Lay-out of a symmetrical rectangular spray cooling pond

(*a*) Plan view
(*b*) Elevation view

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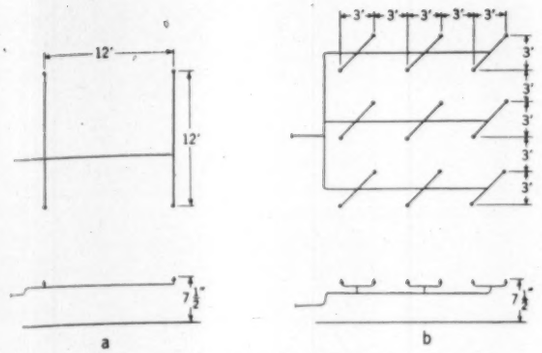


Fig. 2—Lay-out of nozzles for illustrative examples

(*a*) Low pressure unit
(*b*) High pressure unit

the unit volume energy conductance (Ka). This conductance can be used as the basis for the indication of the effectiveness of spray cooling ponds as an energy exchanger. The greater the value of the unit volume energy conductance for a given operating condition, the greater the cooling which results.

For any standard spray pond lay-out, the total spray volume V and the water rate L are functions of the pressure at the nozzles. For example, for a symmetrical rectangular spray pond (see Fig. 1) the volume (V) may be expressed as:

$$[x\,(n_x-1)+F\,(p)\,][y\,(n_y-1)+F\,(p)][z+F'\,(p)\,]\ldots\ldots\ldots\ldots(5)$$

The functions of the pressure $F(p)$ and $F'(p)$ depend only on the type of nozzle. The total water rate L depends on the type and number of nozzles. The total spray volume V may be determined as a function of the pressure if the width and height of the spray are known as a function of pressure for a single nozzle and the lay-out of the nozzles also is known.

By performing a series of tests on any given unit, it is possible to obtain a series of curves for the unit volume energy conductance (Ka) as a function of the pressure at the nozzle for various inlet water temperatures and atmospheric conditions. With the required data on the various types of spray ponds in operation in the industrial sections of the country, a series of performance curves for each type of unit and locality may be obtained. These curves may then be applied directly to the design of spray cooling ponds for any desired operating conditions within the range of available data.

The application of the method proposed for the design of spray cooling ponds will be illustrated by presenting the performance curves of a typical small spray pond with two sets of nozzles (high and low pressure) for what data are available.[3] The lay-out of the two sets of nozzles is shown in Fig. 2, while Fig. 3 shows a cross-section of the nozzles, with the dimensions of the high and low pressure nozzles presented also. For the low pressure nozzles, Equation (5) will be applied to determine the total spray volume as a function of the pressure.

For this case,

x and $y = 12$ ft
n_x and $n_y = 2$
$z = 7\frac{1}{2}$ ft

Substituting in Equation (5),

$$V = [12 + F(p)]^2[7.5 + F'(p)]$$

The operating conditions for run 1 are:

p — 9 lb/sq in. gage	t_2 — 85.5 F
L — 129,100 lb/hr	DB — 57.5 F
t_1 — 160.0 F	WB — 51.5 F

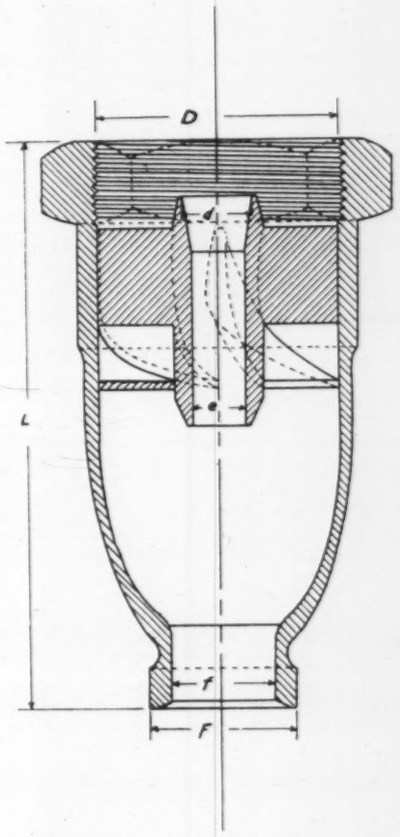


Fig. 3—Cross-section of nozzles for illustrative examples

High Pressure	Dimensions	Low Pressure
1¼ in. pipe	D	2 in. pipe
½ in.	d	⅝ in.
⅛ in.	e	½ in.
⅜ in.	f	1 in.
⅞ in.	F	1⅜ in.
3	No. of Vanes	4
3¾ in.	L	5 in.

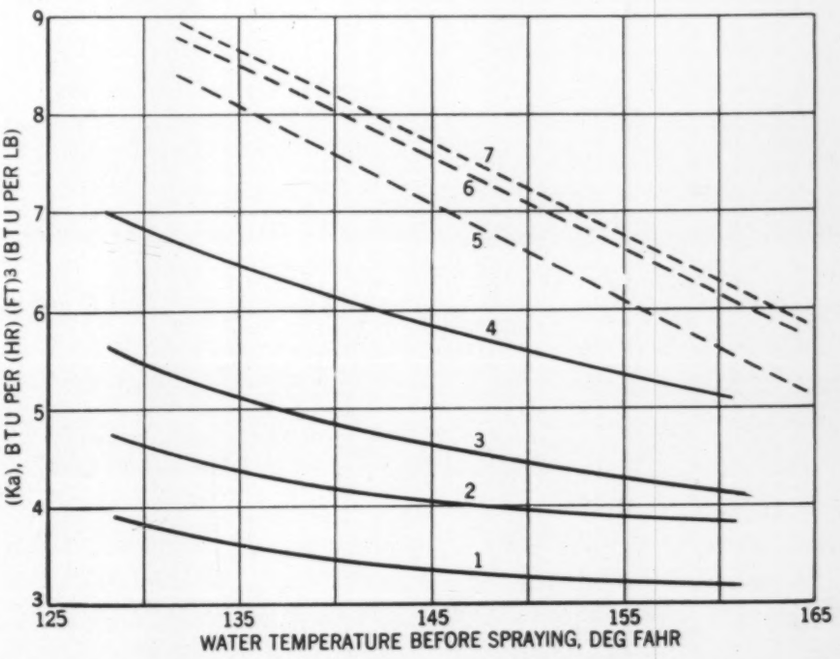
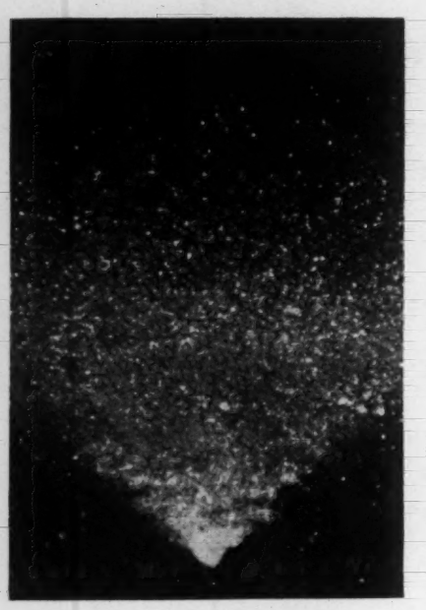


Fig. 4—Unit conductances for illustrative examples for various nozzle pressures

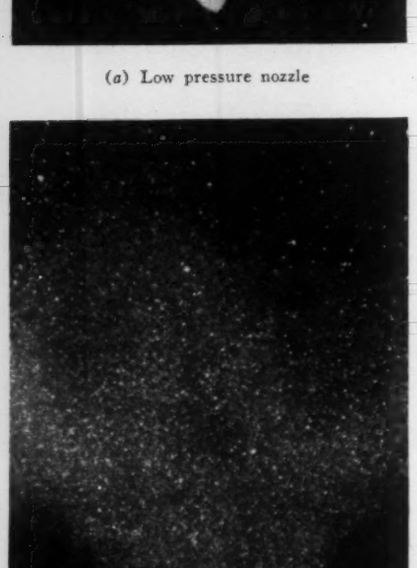
LEGEND

——Low Pressure Unit (4 Nozzles)
1) 3 lb per sq in. gage
2) 5 lb per sq in. gage
3) 7 lb per sq in. gage
4) 9 lb per sq in. gage

——High Pressure Unit (18 Nozzles)
5) 9.2 lb per sq in. gage
6) 7.5 lb per sq in. gage
7) 5.7 lb per sq in. gage



(*a*) Low pressure nozzle



(*b*) High pressure nozzle

Fig. 5—Comparison of drop sizes from nozzles of illustrative examples

For a pressure of 9 lb/sq in. gage at the nozzles,

$$F\ (p) = 22.0 \text{ ft}$$
$$F'\ (p) = 5.0 \text{ ft}$$

Therefore,

$$V = (12 + 22)^2\ (7.5 + 5.0) = 14{,}500 \text{ cu ft}$$

The logarithmic mean potential may be evaluated by obtaining values for the enthalpies at the operating temperatures from a psychrometric chart or a table of thermodynamic properties for moist air.

h''_1 — 373.4 Btu per pound of dry air
h''_2 — 49.8 Btu per pound of dry air
h_a — 21.3 Btu per pound of dry air

Substituting in Equation (3),

$$\Delta h_{lm} = \frac{373.4 - 49.8}{ln\left(\frac{373.4 - 21.3}{49.8 - 21.3}\right)} = 129 \text{ Btu/lb}$$

From Equation (4),

$$(Ka) = \frac{\frac{129{,}100}{14{,}500}\ \frac{(160.0 - 85.5)}{129}}{\frac{8.91\ (74.5)}{129}} = 5.15 \text{ Btu per (hr) (ft)}^3 \text{ (Btu per lb)}.$$

The values for the unit volume energy conductance (Ka) were computed similarly for the various operating conditions and are plotted as a function of the inlet water temperature, as shown in Fig. 4. The performance curves for the high pressure nozzles are also revealed on this figure. The average wind velocity obtained during these tests was probably 3 mph.

Fig. 5 allows a rough comparison of the drop sizes for the two types of nozzles. The smaller drops obtained from the high pressure nozzle increase the amount of cooling per pound of water sprayed, but a greater pressure is required to operate the high pressure nozzles, and a smaller quantity of water is handled per nozzle.

The curves shown in Fig. 4 are applicable only to the systems considered and for the range of experimental and operating conditions investigated. Similar curves obtained for other units and types of nozzles would be valuable as a basis for the design of spray ponds for desired operating conditions.

The application of the design method already illustrated does not include the variation of the unit volume energy conductance (Ka) with atmospheric conditions as sufficient data were not available. The prevailing wind conditions (velocity distribution) will affect the unit volume energy conductance and in order to obtain a complete analysis of the performance of spray cooling ponds, these variables must be taken into account.

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OFFNER APPOINTED HEAD OF N. Y. COMMITTEE

The Honorable F. H. LaGuardia has appointed Alfred J. Offner, New York, N. Y., a member of the Council of the Society, as Executive Director of the Mayor's Engineering Advisory Committee, to aid owners of one- and two-family houses in obtaining low cost, expert advice on all matters relating to fuel conservation and conversion of oil burners to coal burning equipment.

If in the Committee's opinion answers to written inquiries are covered in a pamphlet "War on Fuel Waste—How to Do It," recently prepared by the War Service Committee of the Society, the pamphlet will be mailed, free of charge, in a self-addressed envelope. If a more detailed answer is necessary a printed questionnaire will be sent to the applicant, requesting him to fill it out and return it with a nominal fee of $2.00. If the condition of the dwelling requires a personal inspection and survey, a fee for this service will depend on time consumed and number of surveys in one locality, but will not exceed $10.00.

The Mayor announced that arrangements for this Committee were made through the cooperation of the War Service Committee of the ASHVE, the New York Association of Consulting Engineers, and the New York Chapter of the ASHVE. The project is arranged to function on an actual cost basis, but if any profits result it is understood that these will be given to the Red Cross or the USO.

Medical and Public Health Aspects of Heating Oil Rationing*

By Leverett D. Bristol, M. D., Dr. P. H.
New York, New York

PHYSICIANS, ENGINEERS, and public health workers interested in the subject of indoor heating and ventilation, have become accustomed to think in terms of a so-called "comfort zone", which indicates ideal combinations of room temperature and relative humidity. In the rationing of fuel oil for heating purposes, it may be necessary to reorganize the usual peace-time procedures in the direction of a *discomfort* zone, if it will help to win the war! So far as possible, health should not be jeopardized and if some discomfort or suffering may be required, any rationing plan adopted should be based on justice and equality for all, with special consideration of the needs of those of tender or advanced age, or those with actual disease or lowered vitality. Reasonable and not too drastic regulations should be promulgated in order to prevent a popular uproar and resentment which would defeat the purpose of any plan.

Required changes in national habits in regard to heating and clothing will create extensive opposition. The average person will think he is hit at both ends, if rationing of heating oil is necessary, together with the scarcity of wool and the increased cost of clothing to compensate for reduced temperatures. Therefore, any plan must be preceded and followed through by an intelligent and extensive educational program, using all possible means—radio, newspaper, posters, etc. It must be shown that this is a war in which the average citizen can contribute an essential part.

It would seem desirable to direct such a campaign of health education from some federal agency in Washington, with whatever medical or public health assistance or leadership might be required. Such centralized medical or public health authority assisting the rationing authorities at the federal level also would be of great help in advisory relationships with state and local groups, professional and otherwise; and would serve to instill confidence in the minds of the public on a problem which more than in any other application of the rationing principle yet suggested has important health implications. When people feel cold and chilly, they are going to blame all their ills, real or imaginary, on atmospheric conditions, whether this is warranted or not.

In any educational program some central theme or slogan should be developed and widely promoted. For example, one of the popular songs and slogans of the first world war was, "Keep the Home Fires Burning." For winning the second world war, at least so far as fuel consumption is concerned, a slogan might be, "Keep the Home Fires Burning—*Low*!"

Safe Minimum Indoor Temperatures

What may be considered a safe *minimum* indoor temperature during winter months from the standpoint of health? In the past the error has been on the side of too high temperatures and too dry atmospheres, particularly in private homes and apartment houses. The first essential, therefore, in a fuel and health conservation program is to indicate to the public, particularly those people who have been prodigal in the use of fuel oil, that temperatures must be kept down. In doing this, the other extreme must be avoided of causing so much of a temperature reduction that severe chilling and possible sickness may result. While most winter ills, such as the common cold, influenza, bronchitis, and pneumonia, are due to bacterial and virus infections, scientific evidence is accumulating to show the important relationship of lowered resistance and changes in weather to these conditions.

In the past era of peace and plenty, there has been much concern over the maximum or upper limits of indoor temperature, conducive to health, comfort and efficiency, and there is an abundance of information and scientific evidence to indicate the most suitable combinations of temperature and relative humidity from the standpoint of comfort. On the other hand, there is little experimental evidence of a scientific nature to show what an individual in a wartime economy *can get along without*, or can be cut, in his artificial heat requirements, without injury to health.

After adhering for generations to the idea that ventilation is a chemical problem involving poisonous gases and too little oxygen or too much carbon dioxide, there has been a return to the ideas of the ancients that the problem of ventilation is chiefly physical and has to do largely with air movement, temperature and moisture content. Moreover, ventilation is not so much a matter of what is breathed in through the lungs as it is of how the skin and body react. It is more of a cutaneous than a respiratory problem. Clean air, and air with a chemical composition within reasonably normal limits, is necessary for satisfactory ventilation, but it is more immediately important to ventilate in the interest of the heat regulating mechanism of the body.

Just as an *ideal* temperature, *irrespective of humidity and air motion*, does not exist, so also a *safe minimum* temperature does not exist without these other influencing factors. Without being able to give arbitrarily a *safe* minimum temperature, or danger point, from the standpoint of health, opinions recently gathered from various medical and public health authorities of

*Report, Fuel Rationing Division, U. S. Office of Price Administration, Washington, D. C., September 10, 1942.

the United States, preliminary to the preparation of this report, suggest that the following, without regard to other factors, may be considered *minimum temperatures for emergency requirements* of fuel oil rationing:

(a) For the average private home
—60-68 deg (majority opinion 65 deg)
(b) For the average apartment house
—60-68 deg (majority opinion 65 deg)[1]
(c) For hospitals and sanatoria
—68-80 deg (majority opinion 70 deg except operating rooms 80 deg)
(d) For schools
—60-70 deg (majority opinion 65 deg)[1]
(e) For department stores, office buildings, etc.
—60-68 deg (majority opinion 65 deg)[1]

Indoor temperatures of dwelling places, hospitals, schools, stores, and offices must vary according to the conditions and activities of occupants and the specific uses to which various rooms are put. Granted that industrial efficiency is essential for winning the war, temperatures maintained in industry must be determined on the basis of the particular industrial conditions and needs, and will be less subject to general regulations. However, in the interest of wartime fuel economy, all industries should carefully scrutinize their heating and ventilating equipment and practices to the end that winter indoor temperatures will be kept at the lowest possible point, consistent with the efficiency of the workers.

It has been suggested by some that department stores as a whole might be reduced to lower temperatures (50-60 F dry-bulb), except for the office spaces, since the customers are properly dressed for outside weather and the clerks are fairly active and can dress appropriately.

For general hospital wards a minimum temperature of 65 F may be satisfactory where patients remain in bed, or if ambulatory patients are provided with a 70 deg lounging room. Operating rooms and nurseries naturally require higher temperatures.

In the hospital or sanatorium treatment of tuberculosis, authorities do not feel that reasonably low temperatures (from 60-65 F) are in any way harmful, although they usually prefer 65-72 F. It is agreed, however, that the very low temperatures once advocated have no special merit in treatment. It is believed, in general, that high temperatures (over 70 F) are not necessary and temperatures running to 75 F or over may be definitely undesirable.

It is most important that thermostats in all locations should be properly adjusted and reconditioned, if necessary. The thermostat should be subject to the supervision and manipulation of one person, so far as possible, rather than several different persons. Simple, daily records of indoor temperatures should be kept by householders for more intelligent control of heating. These should cover the day and night temperatures, if feasible.

Procedures to Offset Reduced Temperatures

In a required reduction of the usually recommended indoor temperature of 68-70 F, as a result of the necessary rationing of heating oil, information should be made widely available to the public as to methods and procedures to offset the reduced temperatures and to prevent undue suffering or ill health.

Insulation, Weather-Stripping and Humidification

Reduction of room temperature may be a relatively small item in saving fuel. However, lowering temperature from 72 to 65 F may decrease fuel consumption by 10-20 per cent. Proper insulation of walls and attic floors, the use of storm sash and doors, and so-called vapor barriers, may cut down heat losses by as much as 60 per cent and should be given important consideration by householders.

It may be stated that ventilation is more satisfactory as a rule in the average place of work than in the average home, or apartment house—the latter often being greatly overheated. While mechanical air conditioning equipment may not be feasible in the average home, much may be done to improve conditions for members of a household. It usually has been thought that the chief fault in most homes is the lack of proper indoor humidity; the air of rooms in winter possibly being overdry, with supposed resultant discomfort, and predisposition to various abnormal conditions, particularly of the respiratory tract. However, recent investigations seem to indicate that the usual variations of humidity in homes during the heating season may be relatively unimportant. Limiting or somewhat reducing temperature in the home will simplify the problem of maintaining any required moisture content in the air.

In the interest of conserving health, fuel oil, and the home budget, as well as of winning the war, it should be pointed out that high indoor temperatures are wasteful. While satisfactory air conditioning devices are in use for larger homes, office buildings and other places of work, the home of modest circumstances may have to depend more or less on "home remedies," for the duration. As a matter of fact, some authorities suggest that extra humidification of home indoor air is not nearly so important as people have been led to believe; and even granted that it may be desirable in special cases, it is a high-cost commodity particularly in a wartime economy. At temperatures of 65 F or less, artificial humidification is generally not necessary because laundering, bathing and living activities will result in adequate humidity for normally healthy people. Artificial humidification need be undertaken only upon the specific suggestion of a physician.

Attention to Room Requirements

In homes and apartment houses, little or no attempt should be made to heat the bedrooms, with the exception of those occupied by infants, aged, or ill persons. The bathroom should be kept warm and a schedule set up for dressing and undressing in the bathroom so that bedrooms may be kept at temperatures from 50 to 60 F. Provision should be made for warm night clothes and bed coverings.

Living rooms, where occupants spend most of their time, should be kept at a suitable temperature at the expense of the dining room, halls and kitchen. Kitchen occupants usually are active and additional sources of heat, such as the range and electrical appliances are available. Considerable heating oil savings can be effected by lowering the temperature to 50 deg at night, and by the use of local zone radiant heaters, where electrical power is available for that purpose. Avoid-

[1]Subject to local regulations or codes.

ance of local drafts from windows, doors and fireplaces often may be accomplished by the rearrangement of furniture and, so far as possible, windows and doors should be kept closed, except for minimal essential ventilation. Cold is better borne when the air is still. This should not result in a return to the dark era of *no ventilation*. Pulling down window shades at night screens the cold glass from the rest of the room.

Development of Adequate Health Habits

As a general matter of prevention and health conservation, it is well to remember that a reduced indoor temperature is less apt to injure persons in good physical condition and having good health habits. Plenty of outdoor exercise and sunlight and wholesome food of nourishing quality are most important. Adequate clothing and foot-covering should be worn. Occasional cold baths of short duration may serve to build up resistance in cold-sensitive individuals. The general objectives and effects of these practices should be not so much to "harden" the skin as to improve nutrition, strengthen the muscles, and stimulate the nervous and blood systems. Overfatigue should be avoided. "Early to bed" has both health and fuel-saving values!

Use of Additional Clothing

Indoor comfort and health during the cold months of the year are matters depending just as much on (*a*) individual adjustments of clothing according to personal susceptibility to lower temperatures and drafts, as on (*b*) proper heating and ventilation. So far as reactions to cool moving air are concerned, double comfort standards between men and women, and even individual differences, actually exist and are due largely to differences in dress or clothing, although there may also be minor constitutional differences. As emphasized by Yaglou, reconciliation of this double comfort standard and application of this knowledge to individual situations would do much to prevent dissatisfaction and possible ill effects of cooler indoor temperatures and drafts during the winter.

A heavier dress or suit, an extra undergarment or overgarment, when necessary, may mean all the difference in comfort so far as body reactions to cool indoor air are concerned. Every individual should be brought to realize that he is his own *clothing engineer,* and that he may do much to find winter health and comfort in spite of an overcool room. Wear a sweater and help win the war, may be a worth-while slogan, especially for women members of a household.

The public should be made to understand that by a reasonable amount of extra clothing, the body adjusts itself readily to temperatures at least 10 deg below what people in the United States consider the standard temperature for dwelling houses. Experience of those in foreign countries attests to this fact. Some medical and public health authorities have indicated that not only would it be safe, but actually beneficial to keep temperatures quite a few degrees lower than the commonly accepted standard if additional clothing is worn. The English, based on experience with *radiant* heat, believe that a 60 F dry-bulb temperature is adequate if room occupants are properly clothed.

In any plan to emphasize the use of coal or gas stoves, the public should be warned as to the dangers of possible asphyxiation, poisoning, and fire accidents.

Heating Requirements for Hot Water

Fuel oil rationing must take into consideration and make provision for the need of hot water (if heated by oil) in many domestic activities such as bathing and the sanitary washing of dishes, and other utensils used in common. In homes, public restaurants, cafeterias, drug-store soda fountains and other places of like nature, a definite health hazard exists unless all glasses, dishes, spoons, and cooking utensils are subjected to the necessary cleansing and bactericidal treatment after being used. In many parts of the United States these requirements are contained in state or local health codes or regulations.

Dishwashing devices are classified as (1) hand washing, and (2) machine washing. In either case proper sanitary cleansing and disinfection requires hot water. For hand washing of eating and drinking utensils, the temperature of the soapy water should be as high as can be withstood by the hands—110-120 F. Following this preliminary washing it is usually required that utensils be placed in water of not less than 170 F. The period usually recommended during which these utensils should remain in hot water is from one to two minutes. The pouring of boiling water (212 F) over washed utensils usually is not adequate for disinfecting purposes unless done over a period of at least one minute.

In place of hot water for disinfecting purposes, a chemical bath, preferably warm, of a chlorine solution (100-200 parts per million) may be used, observing about the same time period as above. The wider use of this chemical process for dishwashing would be in the interest of saving hot water and fuel oil.

In machine washing, the temperature of the soapy wash and the rinse water should not be less than 170-180 deg properly controlled as to time, usually two minutes. In exposure of utensils to live steam, this usually is done in a closed compartment for at least five minutes.

Supplement Fuel Oil Rations

Special regulations should be set up to provide supplemental fuel rations for the following homes:

1. Those in which there are young children under four years of age. During these early years of life children require frequent bathing in rooms which must be adequately heated. They spend much time on the floor where temperatures are several degrees lower than at the shoulder height of a sitting or standing adult. A room temperature of not less than 70 F should be provided. This also would take care of the needs of the nursing mother.

After the fourth birthday, children become more active and begin considerable outdoor life. This play and extra activity continues during school years. There also is more opportunity for insistence on sufficient clothing, regardless of style, than among adults. School children are away from home for part of the day, during which their artificial heating needs are taken care of by the school authorities. Moreover, children produce more heat in proportion to their body area than do adults. If anything, normal children need a cooler and not a warmer environment than adults. Except in unusual instances, no supplemen-

tary home fuel oil ration would seem to be necessary.

2. Those in which there are older people, particularly those of lowered vitality. There are more individual differences in this age group, which may have to be taken into consideration as special cases. Some people are "old" at 55 years of age while others are still "young" at 70 years. In general, supplemental rations should be made available for homes with one or more occupants over 65 years of age. In such instances a temperature of not less than 70 F and possibly as much as 74 F for the room or rooms occupied should be provided, based on home conditions and needs.

3. Those homes in which there are one or more cases of acute or chronic sickness or invalidism. Since the medical treatment of these cases usually includes directions or orders from a physician as to the upward or downward regulation of room temperature, he should be the judge of the need for possible supplementary fuel oil rations.

Administration and Certification

It must be assumed that the local rationing board, made up of competent authorities, will have the power to investigate and pass upon all requests for supplementary fuel oil rations. Their attention must be given to many matters, such as the difference in insulation and the efficiency of the heating plant in homes requesting supplementary rations.

Certification by a licensed physician should be made to the rationing board for supplemental fuel oil rations in all cases involving actual needs arising out of sickness and the infirmities of old age or other special cases. This should include the probable time during which supplemental rations will be required. Supplemental rations should be made available for a definite period of time based on local conditions and needs, and renewal or extension of such rations should be provided as might be required. Physicians should not be asked to reveal a diagnosis when that violates an ethical confidence.

The amount of the additional allotment should be determined by the local rationing board on the basis of the doctor's certification as to the indoor temperature required and the board's decision as to the extra amount of oil needed to attain that temperature. To expedite the interests of the sick individual, protect the physician, and safeguard the interests of the public in this important war-emergency measure, it might be desirable to have the physician's certificates filed (*a*) by the local rationing board in those communities where a local physician is appointed as consultant or advisor to the board, or (*b*) by the local health officer where this is not the case. The value of designating a local physician as a consultant or advisor to the local rationing board should be carefully considered.

Finally, any plan of heating oil rationing should take into consideration not only the possible periods of abnormally cold weather and increased precipitation of snow or rain, but also must be patterned so that adjustments in the value of fuel oil coupons may be made in the presence of epidemics or threatened epidemics of such diseases as influenza. Moreover, communities which may accurately be described as health resorts should be given special consideration.

The Fuel Rationing Division of the United States Office of Price Administration is to be commended for their early recognition of the important medical and public health implications in applying the rationing principle to oil for heating purposes, as a war-emergency measure.

This period of rationing will be an historical demonstration of what the people in the United States can stand with reference to a minimum indoor temperature. Let us go forward with courage and confidence, fully determined to beat our enemies, both on the outdoor and the indoor front!

Acknowledgments

Grateful appreciation is expressed to the following medical and public health authorities, who have cooperated whole-heartedly in supplying opinions, published articles, reports and other material, which have been used extensively in the preparation of this report:

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DELTA MEMBERS MEET

August 11, 1942. The regular monthly meeting of the Delta Chapter was held at Arnaud's Restaurant with 9 members and guests at luncheon. The meeting was called to order by Pres. G. C. Kerr, and the minutes of the last meeting were read and adopted.

G. E. May, chairman of the Blackout Committee, reported that he turned his final report over to the Office of Civilian Defense, and Alcee Legendre, coordinator for the OCD in this area, suggested that material submitted to him would be printed in pamphlet form for distribution.

A committee composed of Messrs. J. J. Bryner, N. J. Helwick, R. B. Guest, and F. P. Fischer, was appointed by President Kerr to make a survey of the local fuel situation in connection with the Fuel Conservation Program. After a lengthy discussion at the meeting it was decided to await a report of the findings of this committee.

A decision was also made to compile a new roster designating the active members, the members in the armed forces and the members out of town on defense jobs, and this was followed by adjournment.

A Modulating Electronic Temperature Control†

By Walter R. Elliot,* Columbia, Mo.

THIS TEMPERATURE control was evolved incidental to experimental work on heat transfer and vapor diffusion. Its prime purpose was to eliminate the lag which may occur when a liquid-filled thermostat is used to control the temperature of a moving stream of air. In cases where the mass flow of air is inconsiderable, this lag becomes very pronounced owing to the small heat capacity of the air.

If the lag in the apparatus is to be substantially reduced, it is essential that the control element in the air stream should have the least possible heat capacity. In this research work excellent control was obtained by using a resistance thermometer in a Wheatstone bridge circuit. The thermometer itself was directly in the air stream.

This resistance thermometer was constructed of No. 36 B. & S. gage nickel wire. The wire had a resistance of 2.1 ohms per foot, and the thermometer had a total resistance of 602 ohms at 68 F. The wire was wound on two No. 6 pyrex glass tubes 15 in. apart. Small beads of glass were fused onto the tubes as spacers to keep the nickel wires from touching. These wires were soldered at the ends to Fahnestock clips, and constantan leads went from the resistance thermometer to the control apparatus. The wiring diagram for this temperature control is shown in Fig. 1.

The KU 627 tubes are Westinghouse grid-glow tubes (thyratrons). They are mercury vapor tubes, and carry a current of 2.5 amperes each. The total heat input of which these tubes are capable is therefore 550 watts, and this is delivered to heating coils located upstream from the resistance thermometer.

One arm of the Wheatstone bridge is the resistance thermometer. Another arm consists of a fixed resistance of 2600 ohms. The control which determines the temperature at which the circuit will balance consists of two resistances of 20 and 500 ohms. Moving the latter has the effect of decreasing the resistance in one arm and increasing it in the adjacent arm of the bridge, which also has a fixed resistance of 2600 ohms.

The operation of the modulating temperature control may be briefly described as follows: If the air passing the resistance thermometer becomes slightly cooler than the temperature at which the bridge is in balance, the resistance of the resistance thermometer decreases slightly and the bridge circuit becomes unbalanced. This unbalance of the bridge is amplified by the 57 tube and amplified again by the 56. This amplified unbalance is fed to the grids of the 53 through the biasing transformer. The 53, acting as a rectifier, feeds the grids of the thyratrons through the phase-shifting network. With the grids positive with respect to the cathodes, the mercury vapor tubes become conducting, carry a current, and impress a heating load on one of the heating coils. The higher the positive voltage on the grids becomes, the higher is the heating current that the tubes carry.

When the air is heated up to the operating temperature, the circuit in the return of the 56 and 57 supply tends to make the potential of the 56, 57 and thyratron cathodes slightly positive with respect to ground. This causes the thyratrons to be non-conducting, and no heating load is carried.

This particular circuit was constructed to control air conditions over a temperature range of 60 to 115 F. In experimental work where it was used no temperature variation in the moving air stream was observed as great as 0.1 F. If fluctuations in the ambient temperature are small, control may be even more precise.

†Work done as a Research Fellow at Purdue University.

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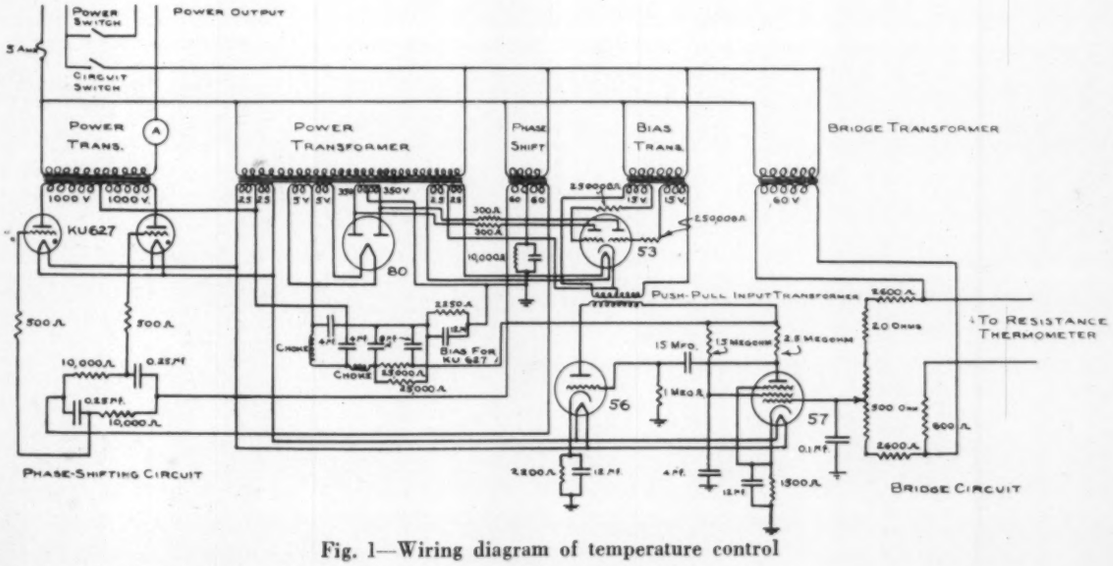

Fig. 1—Wiring diagram of temperature control

The Application of the Effective Temperature Scheme to the Comfort Zone in Netherlands India

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SUMMARY—This paper reports an investigation into the effective temperature scheme for Netherlands India based on a representative group of 21 subjects. The Mollier Chart was used for superimposing the effective temperature lines and the comfort zone. The Assmann psychrometer was taken as a standard for both the dry- and wet-bulb temperatures observed. The final slopes of the effective temperature lines were drawn from the corrected Assmann readings. A comparison was made between the effective temperature lines developed in U.S.A. and those found in the experiments for Netherlands India.

Introduction

In the United States of America, Houghten, Yaglou[1] and others have devised the effective temperature scheme for assessing climate and have carried out large-scale experiments in order to determine the comfort zone and equal comfort or effective temperature lines for American subjects. However, such results obtained for Americans, do not of necessity apply to residents of Netherlands India.

In order to assess climatic conditions in factories, houses, offices, theaters, air-raid shelters, etc., it would be convenient to have available the effective temperature scheme obtained for residents of Netherlands India. Then by the application of methods of ventilation and air cooling the prevailing conditions may be changed to optimum living and working conditions. But, it may be asked, what are the optimum working conditions and what is the optimum effective temperature?

Radsma[2] has demonstrated that basal metabolism is lower for inhabitants of tropical coastal regions than for those of temperate climates. But he has also shown by a statistically adequate series of experiments that during a temporary stay in a cool room, the resting metabolism of tropical inhabitants becomes lower than in their ordinary tropical atmosphere[3]. Thus he concludes that the lower resting metabolism in the cool room signifies that even under the most favorable tropical conditions, bodily metabolism does not fall—or rather cannot fall, to the same extent, as when the subject is resting in a cooled environment.

In extensive investigations in Batavia, Radsma[3] has demonstrated the following effects produced on tropical inhabitants by a temporary stay in a cool environment: less skin activity not only as a result of less sweating but also as a result of less lactic acid secretion, approximately the same blood pressure with probably a somewhat diminished minute volume of the circulation, slower pulse rate, an adaptation of the circulation by diminution of the quantity of extracellular body fluid and a lower resting metabolism.

He draws the conclusion that it is possible for the human body to rest more profitably in a cool environment than in a tropical atmosphere.

It is a well-known fact that man remains healthier for a much longer time in a temperate climate than in a tropical atmosphere. This difference should be associated with differences in physiological functions of the human organism. Obviously, the human organism derives definite advantages from a cool atmosphere.

Perhaps the most striking physiological difference demonstrated by Radsma[4] between tropical inhabitants and inhabitants of temperate regions is the raised body temperature in the tropics. He has proved statistically that not only the sublingual temperature but also the rectal temperature of man during the day in the tropics is 0.3 — 0.4 C higher than in temperate climates. This is indeed a very significant difference for one of the most constant of bodily constants.

Radsma suggests that the higher body temperature is a necessary stimulus to the heat regulating centers to facilitate heat loss from the body.

From a physiological viewpoint, therefore, the tropical man should be provided with a cool environment, so that body heat loss may be facilitated. In this way, the man in the tropics will be able to work under circumstances comparable with those prevailing in temperate regions.

In previous papers by Mom[5, 6] and Wiesebron[7] a comfort zone for men clad in ordinary tropical clothing in Netherlands India was established.

The climatic conditions in this case were evaluated in terms of dry-bulb temperature and relative humidity, while all determinations were carried out in still air.

It may be stated here with reference to a recent elaborate paper of Lee on this subject[8], in which he discusses the previously described work, that the purpose of these experiments was to make an outline of the comfort zone in Netherlands India under the simple circumstances of the psychrometric experiments as previously stated.

For the purpose of delineating the comfort zone on a Mollier diagram it was not necessary to make use of the effective temperature scheme, as has been developed by Houghten and Yaglou. The experimental data of this research were recorded only in terms of dry-bulb temperature and relative humidity, two simple but exact measures which have no pretention to more meaning than they really have.

However, in order to carry out further investigations into the influ-

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[1]Numerical exponents refer to references.

ence of other factors on the situation of the comfort zone, it becomes necessary to incorporate temperature and humidity in one entity. Therefore, the effective temperature scheme was adopted in the experiments described herein. This scheme has proved to be of great practical value in many instances. However, one must be aware of the intrinsic defects of the effective temperature measure and it must be realized that although there may be two conditions of different temperature and humidity in which the actual feeling of comfort is exactly the same, the *potential* state of comfort of the subject can be different.

For instance, as has been pointed out by Wiesebron[7] a person may be quite comfortable in almost saturated air of 22 C dry-bulb temperature, but under these circumstances he is undoubtedly much nearer discomfort than at the same effective temperature point of 22 C with a dry-bulb temperature of 24 C and a relative humidity of 62 per cent.

Pursuing the experiments concerning human comfort in Netherlands India, the authors desired to investigate the influence of air velocity and radiation. These investigations of the effect of air velocity and radiation, on which the authors are still at work, using the effective temperature scheme, will be reported later.

With regard to the number and quality of test subjects the same technique was followed as in the previous investigations. The advantages of this technique, using a limited number of selected test persons who are well fitted for the purpose, were explained previously by Wiesebron[7, a].

Table 1—List of Test Subjects

Subject	Sex	Age	Race
1. Ke.	f.	20	Eur. (b)
2. Soen.	m.	23	Ind.
3. Ki.	m.	32	Eur.
4. Co.	m.	22	Eur. (1)
5. Ve.	f.	19	Eur. (b)
6. Soet.	m.	23	Ind.
7. Th.	m.	27	Chin (b)
8. Dj.	m.	42	Ind.
9. Ka.	m.	27	Ind.
10. Kh.	m.	22	Chin.
11. La.	f.	19	Eur. (b)
12. Si.	f.	27	Eur. (b)
13. Soed.	m.	26	Ind.
14. Kl.	m.	20	Eur. (b)
15. Sch.	m.	34	Eur.
16. Ho.	m.	41	Chin. (b)
17. Ba.	f.	25	Eur.
18. Schsr.	m.	64	Eur.
19. Bau.	m.	41	Eur. (b)
20. Scha.	m.	42	Eur.
21. Wi.	m.	36	Eur. (b)

b—Born in Netherlands India.
1—Born in Australia.

Present Investigation

Plan of Experiments: In this series of experiments there were 21 subjects consisting of students and members of the staff of the Laboratory. Particulars about these subjects are given in Table 1.

Two psychrometric rooms with an inter-connecting passage-way were used for the experiments. Details of the structure of these rooms and of the method of their air conditioning may be read at length in a treatise by Wiesebron[7].

The temperature and relative humidity could be quickly altered in each room, but great care was taken not to alter these conditions so quickly as to confuse the subject. At first the two rooms were used, completely shut off from the inter-connecting passage-way. Later, however, it was found easier for the subject to record his feeling of comfort more accurately by including the passage-way in *Room B* so that the subject passed immediately from one atmosphere to the other.

In *Room A* a relative humidity of 35 to 55 per cent was maintained, with varying temperatures, while in *Room B* the relative humidity varied from 80 to 100 per cent. This high relative humidity was maintained by means of three water-vapor blowers situated on the walls of *Room B* and operated by means of an electric air pump.

An observer sat in each psychrometric room and recorded dry-bulb temperature, wet-bulb temperature and the comparative feeling of comfort of the subject, whether one atmosphere was hotter than, cooler than, or the same as the other. At first, the subjects were under observation for only a few minutes, that is, until an equal comfort line was obtained for them by adjusting conditions in one or both rooms. With some subjects, however, this method did not give consistent results and the reason was perhaps to be found in the desire of the subject to please the observer and also to return as quickly as possible to his or her own particular task.

Soon after the commencement of the investigation this method was changed to one whereby the subject was kept under observation for one hour. During this time he frequently passed from one room to the other and expressed his comparative feeling of comfort in the two rooms.

During the hour the conditions in both rooms were gradually altered over a range of approximately 3 deg ET and on an average 8 to 10 equal comfort lines were established. This method gave much more consistent results and one hour in the psychrometric rooms did not appear to tire the subject so that he could still give faithful results at the end of one hour. A typical hour's results are given in Table 2, and a typical day's results are shown in Fig. 1. Thus, during one day's observations conditions were gradually changed from 17 deg ET to 28 deg ET for four or five subjects.

Use of the Mollier Diagram:[9, 10] This diagram which is a psychrometric chart gives the relationships of one kilogram of dry air mixed with varying amounts of water vapor and it is true for a certain constant barometric pressure.

Though it is perhaps superfluous, it may be stated that the nearly horizontal lines spreading a little fanwise are the isotherms; the oblique parallel lines are lines of constant heat content, which for practical purposes may be considered as identical with wet-bulb lines, while the upward spreading curved lines are

Table 2—Typical Data for an Hour of Observation

Room A		Room B		Feeling of Comfort
Dry-Bulb	Wet-Bulb	Dry-Bulb	Wet-Bulb	
21.8	15.5	19.9	17.35	Room A a little warmer
21.0	15.0	19.6	16.25	A and B equal
22.0	14.9	20.0	17.8	A and B equal
22.6	15.2	20.6	18.05	A little warmer
22.5	14.9	20.85	18.3	A little warmer
22.4	14.7	21.0	18.45	A and B equal
22.8	14.7	19.9	19.5	A and B equal
23.2	15.2	21.3	19.6	A cooler
23.5	15.6	21.55	19.6	A warmer
23.3	15.4	21.6	19.6	A and B equal
24.2	16.2	22.2	20.5	A warmer
24.0	16.0	22.2	20.5	A and B equal
24.8	16.9	22.3	20.6	A little warmer
24.3	16.5	22.7	20.7	A and B equal
25.0	16.6	23.2	20.9	A and B equal

[a] Wiesebron reports that not everybody is suitable as a test subject. As a human being the test person will always cooperate with the investigator or work in opposition to him. Therefore the test person must possess a certain intelligence and moreover he must be experiment-minded. He should be of such a mental and physical disposition as to react consistently to the influences of temperature and humidity.

In accordance with that, it was experienced that generally the subjects acquired a more critical and exact judgment of the circumstances prevailing in the test room, so that the delineation of the comfort zone could be made more sharply. It may be stated that Houghten and Yaglou report a similar happening in their experiments. Hence the conclusion was made that it is preferable to work with a small number of suitable subjects rather than with a large number of any given persons, unless the number taken can be extremely great.

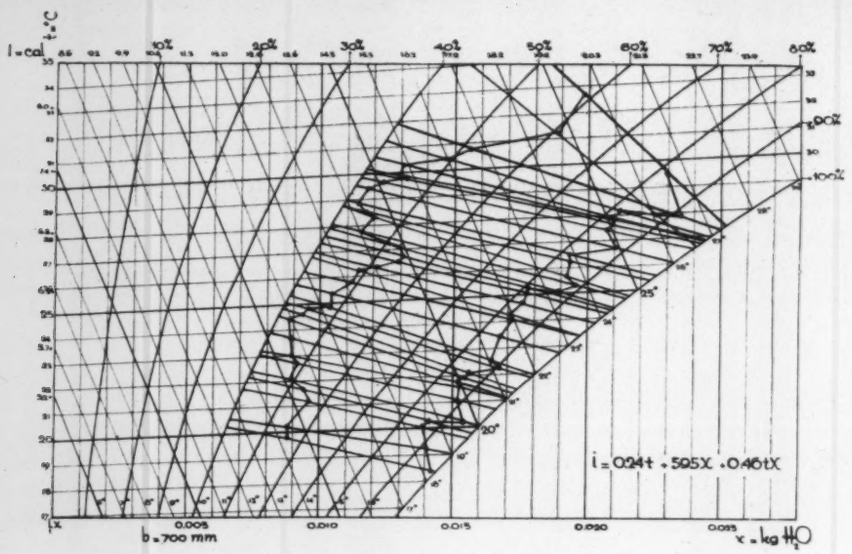

Fig. 1—Mollier diagram showing typical test results for one day

lines of constant relative humidity. The Mollier diagram is one with oblique axes. On the vertical axis the heat content i is measured in kcal for $1 + x$ kg of dry air-water-vapor mixture, while the water-vapor content x is originally plotted on the oblique axis as kg of H_2O-vapor.

The horizontal line through the origin is used as an auxiliary x-axis, as a matter of convenience.

The diagram is constructed according to the following equation:

$$i = 0.24t + 0.46tx + 595x \quad \ldots (1)$$

where i = heat content in kcal, the zero being dry air at 0 C. So air of 0 deg and water of 0 deg both have a heat content of 0 kcal/kg.

x = amount of H_2O-vapor present in 1 kg of air (hence there is always 1 kg of dry air together with x kg of H_2O-vapor).

$$x = 0.622 \frac{p}{B - p} \quad \ldots (2)$$

p = vapor pressure of H_2O.

B = barometric pressure = 700 mm for Bandoeng.

0.622 is the ratio between the weights of water vapor and air under the same circumstances $= \frac{0.804}{1.293}$ = weight of H_2O vapor/weight of air.

0.24 = specific heat of dry air.

0.46 = specific heat of water-vapor.

595 = heat of evaporation of 1 kg of H_2O at 0 C.

t = temperature in C.

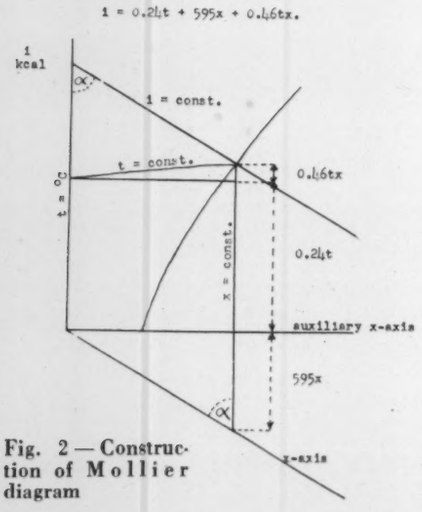

Fig. 2—Construction of Mollier diagram

In most cases Mollier diagrams are constructed with the 0 deg isotherm as the base-line, as can be seen in Fig. 2. In order to obtain greater accuracy, however, and since the comfort zone was of main interest in this work, it was decided to use only that part of the diagram, which measures effective temperatures ranging from 17 C to 29 C.

In the construction of the diagram we fixed both 1 C measured on the vertical axis and 0.001 kg of H_2O-vapor, measured on the horizontal auxiliary x-axis, as 1 cm. Therefore, 1 kcal is represented vertically by $\frac{1}{0.24} = 4.17$ cm and horizontally by $\frac{1}{0.595} = 1.68$ cm.

Therefore, the tangent of the angle made by the constant i-line with the horizontal in this diagram is $4.17/1.68 = 2.48$.

Table 3 gives the figures necessary for the construction of that part of the Mollier diagram from 17 C to 29 C ET.

Various stages in the formation of the Mollier diagram by use of the data found in Table 2 are given in Figs. 3-7.

Fig. 3 shows the construction of the saturation line and the isotherms from 17 C to 29 C for whole numbers of degrees by plotting on the auxiliary x-axis the values for x (column 4, Table 3) and on the y-axis the values of $0.24t + 0.46tx$ (columns 5 and 8, Table 3). As can be seen in this figure the isotherms are at an angle with the horizontal, which angle increases with the temperature.

Fig. 4 shows the construction of the constant i-lines, drawn parallel to the x-axis through the points of intersection of the isotherms with the saturation line. These constant

Table 3—Data Required for Construction of Mollier Diagram from 17 to 29 C

1	2	3	4	5	6	7	8	9	10
t DEG C	p (MM HG)	x (KG H_2O-VAPOR)	x (CM)	$0.24t$ (KCAL)	$595\,x$ (KCAL)	$0.46t\,x$ (KCAL)	$0.46t\,x$ (MM)	i (KCAL)	i (CM)
6	7.013	0.006295	6.3	1.44	3.745	0.01738	—	5.202	21.7
7	7.513	6748	6.75	1.68	4.015	2173	—	5.717	23.8
8	8.045	7231	7.2	1.92	4.303	2662	—	6.250	26.0
9	8.609	7747	7.75	2.16	4.609	3207	—	6.801	28.3
10	9.209	8292	8.3	2.40	4.934	3815	—	7.372	30.7
11	9.844	8874	8.9	2.64	5.279	4490	—	7.964	33.2
12	10.518	9498	9.5	2.88	5.646	5240	—	8.578	35.75
13	11.231	0.01014	10.1	3.12	6.033	6063	—	9.214	38.39
14	11.987	1109	11.1	3.36	6.445	6976	—	9.875	41.14
15	12.788	1158	11.6	3.60	6.889	7989	—	10.569	44.04
16	13.634	1235	12.35	3.84	7.348	9090	—	11.279	46.99
17	14.530	1318	13.2	4.08	7.845	0.1031	4.3	12.028	50.12
18	15.477	1406	14.1	4.32	8.368	1165	4.86	12.805	53.33
19	16.477	1500	15.0	4.56	8.923	1311	5.5	13.614	56.70
20	17.535	1599	16.0	4.80	9.510	1471	6.1	14.457	60.26
21	18.650	1702	17.0	5.04	10.13	1644	6.9	15.334	63.87
22	19.827	1813	18.1	5.28	10.79	1835	7.65	16.254	67.70
23	21.068	1930	19.3	5.52	11.48	2042	8.5	17.204	71.66
24	22.377	2054	20.5	5.76	12.22	2268	9.5	18.207	75.88
25	23.756	2186	21.9	6.00	13.00	2514	10.5	19.251	80.21
26	25.209	2324	23.2	6.24	13.82	2780	11.6	20.338	84.70
27	26.739	2471	24.7	6.48	14.70	3069	12.8	21.487	89.54
28	28.349	2625	26.25	6.72	15.63	3383	14.1	22.688	94.54
29	30.043	0.02789	27.9	6.96	16.59	3720	15.5	23.922	99.63
30	31.824	2962	29.6	7.20	17.62	4088	17.0	25.229	—
31	33.695	3146	31.5	7.44	18.72	4496	18.7	26.610	—
32	35.663	3338	33.4	7.68	19.86	4914	20.5	28.031	—
33	37.729	3542	35.4	7.92	21.08	5378	22.4	29.538	—
34	38.898	3760	37.6	8.16	22.38	5882	24.5	31.128	—
35	42.175	3988	39.9	8.40	23.73	6422	26.75	32.772	—

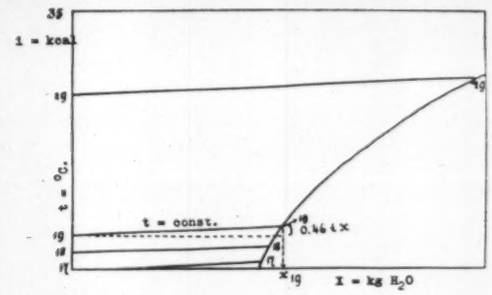

Fig. 3—Development of saturation line

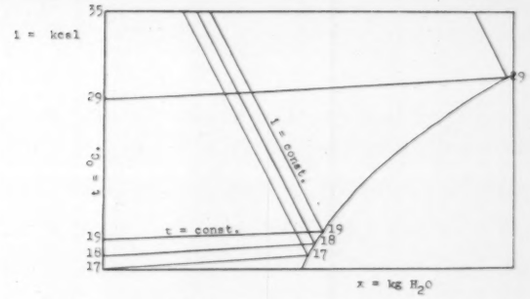

Fig. 4—Construction of constant *i*-lines

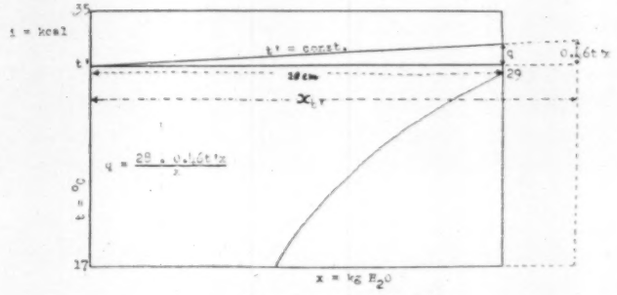

Fig. 5—Location of isotherms

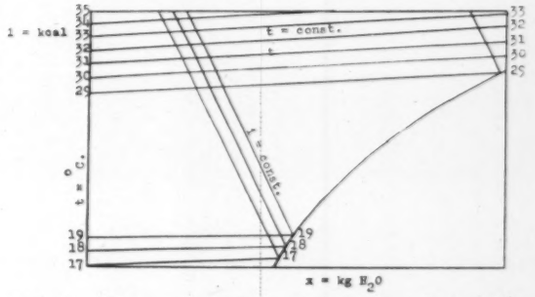

Fig. 6—Diagram showing isotherms and constant *i*-lines

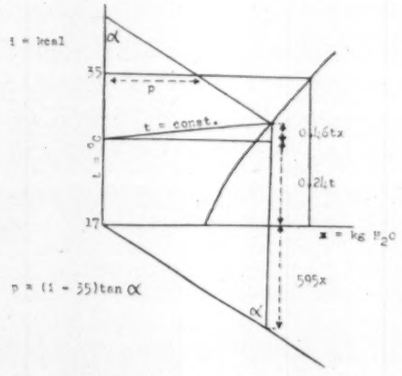

Fig. 7—Construction of the 12 to 16 C constant *i*-lines

i-lines are considered for the present as wet-bulb lines.

Fig. 5 shows the construction of the isotherms from 30 C to 34 C by first determining the points of intersection of these isotherms with the constant x-line for $x = 0.028$ kg H_2O

$$q : 28 = a : x$$

$$a = 0.46t'x$$

$$q = \frac{28.\,0.46t'x}{x}$$

using columns 4 and 8 of Table 3.

Fig. 6 shows the part of the diagram already constructed, *i.e.* the isotherms from 17 C to 34 C with the corresponding constant *i*-lines.

The construction of the 12 C to 16 C constant *i*-lines is shown in Fig. 7, by determining the point of intersection of these constant *i*-lines with the $t = 35$ C-line using the values of i in cm from Table 3 (column 10)

$$p = (i - 35) \tan \infty$$

The i = constant lines for 6 C—11 C may be drawn by use of: (*a*) the values of i; (*b*) $\tan \infty = 2.48$. Finally the lines of relative humidity are also included. Each line of constant t is divided into 10 equal parts and the corresponding points joined.

Investigation of Results: In every case of equal comfort the conditions prevailing in *Rooms A* and *B* were plotted on the Mollier diagram (the constant *i*-lines being used as wet-bulb lines) and corresponding points joined by straight lines to be designated equal comfort or effective temperature lines.

By doing so, it was assumed that points of equal comfort lie on a straight line throughout the whole range of relative humidity. This assumption seemed justified firstly in accordance with the results found by Houghten and Yaglou[1]; secondly with the fact that the borders of the comfort zone as determined by Mom[5] and Wiesebron[7] are almost straight lines. Although these borders are not equal comfort lines as determined by passing from one room to the other, they are in a sense equal comfort lines for conditions which are judged after a longer time of exposure.

Moreover, the small correction involved by determination of points of equal comfort throughout the whole range of humidities would not compensate for the amount of work necessary. Lines of equal comfort or effective temperature lines were drawn for each subject on a separate Mollier diagram. On an average, there were some 40 effective temperature lines for each subject. The next step was to determine the slope of each effective temperature line, such slope being the angle subtended to the horizontal (accurately measured to 1/10 in each case).

In most cases the angle made by the effective temperature lines with the horizontal, increased as one passed from lower to higher effective temperatures, but the reverse was the case in some subjects. That the slope of the effective temperature lines should become steeper as higher temperatures are reached, is in conformity with the well-recognized fact that sweating at higher temperatures causes the body to approach more closely to a wet-bulb thermometer while at lower temperatures, in the absence of perspiration, the body behaves more in accordance with that of a dry-bulb thermometer. This is well seen in the subject Ki in Fig. 8.

However when another subject is taken, *e.g.* Soen (Fig. 9), it will be seen that there is a marked contrast with that found for the subject in Fig. 8. The slope of the 28 deg ET line for subject Ki is ± 45 deg while that for subject Soen is ± 16 deg. This large discrepancy appears to be a direct consequence of the difference in sweating ability of the two subjects, for whereas sweat was very abundant on the forehead and face

of Ki, it was still entirely absent in Soen under the same conditions.

With such contrasts the difficulty of obtaining an effective temperature chart accurately applicable to all subjects, can be readily appreciated. However, great differences were only manifest at higher temperatures which were above the upper limit of the comfort zone, so that within the comfort zone, the chart obtained may be said to be sufficiently accurate for practical purposes.

The next step was to plot on a graph, effective temperatures on the y-axis against the corresponding slope of the effective temperature line on the x-axis. By doing so, it was found that the distribution of the points was such as to suggest a linear relationship. The *Line of Best Fit* through these points was calculated from the following formula:

$$y - \bar{y} = B(x - \bar{x})$$

where

$$B = \frac{\Sigma YY}{\Sigma XY}$$

$$X = x - \bar{x} \text{ and } \bar{x} = \frac{\Sigma x}{n}$$

$$Y = y - \bar{y} \text{ and } \bar{y} = \frac{\Sigma y}{n}$$

y = effective temperature in degrees Centigrade.

x = slope of the effective temperature line in degrees.

B = tangent of the slope of the line and x, y represent the coordinates of the center of gravity of all the readings.

B was calculated from the formula $\frac{\Sigma YY}{\Sigma XY}$ because, in the Netherland India case, the effective temperature represented by y is much less influenced by subjective variation than the slope of the effective temperature line, which is measured by the feelings of the subject. The formula $\frac{\Sigma YY}{\Sigma XY} = B$ is applicable to those cases in which the y values are measured with much more certainty than the x values, such as prevailed in our case. This can be elucidated by drawing the following two equal comfort lines on a Mollier diagram:

D.B.	W.B.	D.B.	W.B.	Feeling of Comfort	E.T.	Slope
22.0	14.9	21.0	18.0	Equal	20.2	11.0 Deg
23.0	13.3	21.0	18.0	Equal	20.0	15.0 Deg

The second point is the same in each case and a difference of 0.2 deg ET corresponds to a difference in the slope of the effective temperature line of 4.0 deg.

In Table 4 are given the lines of best fit for each subject, together with the number of effective temperature lines and the correlation coefficients between effective temperature and the slope of the effective temperature line.

Determination of the Line of Best Fit for All Subjects: In determining the *Line of Best Fit* for all subjects, equal importance was attributed to the slope of the *Line of Best Fit* for each subject.

The values of x for effective temperatures of 17 deg and 29 C were determined for each subject and also the mean values for all subjects. In this way the *Line of Best Fit* for all subjects was found to be the following:

$$y = 1.813x - 10.08$$

where y = effective temperature and x = angle subtended to the horizontal by the effective temperature line. This formula is shown in Table 5.

Fig. 10 shows a Mollier chart with superimposed lines of effective temperature in accordance with the *Line of Best Fit* obtained for all subjects.

In the experiments accuracy was sacrificed to a certain extent for convenience firstly by considering the constant i-lines in the Mollier diagram as wet-bulb lines, and secondly, by considering the psychrometric readings as true theoretical

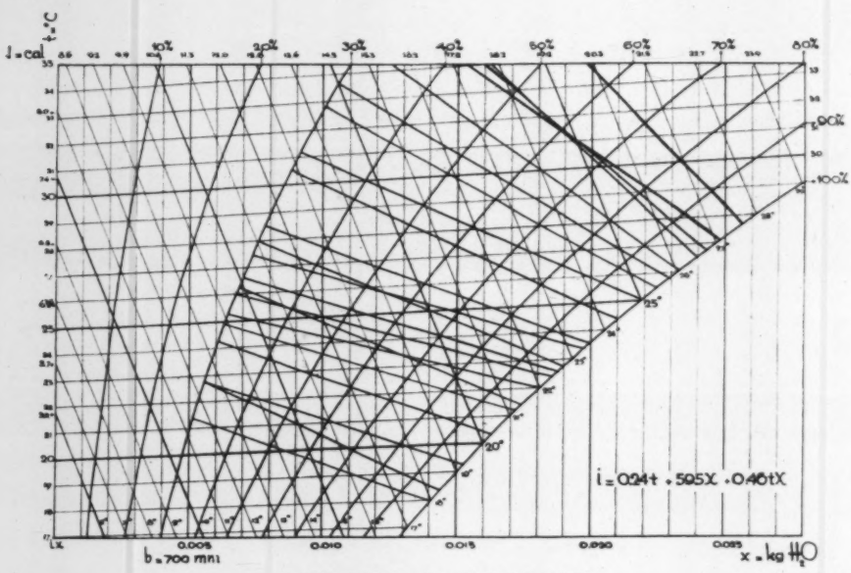

Fig. 8—Results of Subject Ki

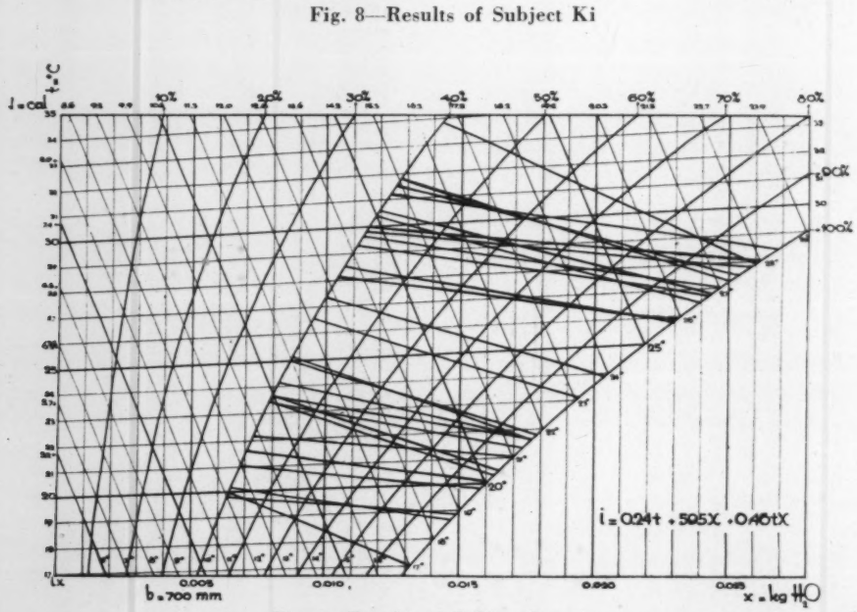

Fig. 9—Results of Subject Soen

values. So the chart in Fig. 10 may be considered as a preliminary chart which must be converted into one giving real values. This method was chosen because the correction of the calculated results entailed much less work than would have been necessary for correcting each separate reading.

Correction of the Preliminary Chart

Correction of Psychrometric Readings Made During the Experiments to Assmann Psychrometric Readings: In accordance with results found by Wiesebron in previous investigations, the Assmann psychrometer was taken as standard, because it was found to be the most accurate type of psychrometer available.

As the Assmann psychrometer, however, is rather unsuitable for continuous readings, because the clockwork fan in this instrument must be wound up before every reading, a psychrometer especially constructed for continuous readings was used in the present experiments. This psychrometer consisting of a dry- and a wet-bulb thermometer placed within a metal cylinder of 20 cm length and 12 cm width, with a small electric fan at one end of the cylinder, was described extensively by Wiesebron together with the results of an elaborate test[7]. In this report it is referred to as the *electrical psychrometer*. The readings of this psychrometer were corrected to Assmann readings.

Experimental conditions were reproduced in both rooms and simultaneous readings were carried out with the Assmann and electrical psychrometers. For *Room A* the relative humidity averaged about 40 per cent while the dry-bulb temperature varied from 20 C to 34 C. For *Room B* the relative humidity was maintained at approximately 90 per cent with the dry-bulb temperature varying from 17 C to 29 C.

The readings were plotted on a graph from which it was evident that there existed an approximate linear relationship between temperature and the difference between Assmann and electrical psychrometric readings, both for dry-bulb and for wet-bulb temperatures. In each case, the exact difference was calculated and also the mean difference, giving the following relationships:

Room A (dry atmosphere)

Electrical psychrometer I

Assmann D.B. = D.B. recorded (E.P.) —0.15

Assmann W.B. = W.B. recorded (E.P.) —0.45

Room B (wet atmosphere)

Electrical psychrometer II

Actual D.B. = D.B. recorded (E.P.) —0.31

Actual W.B. = W.B. recorded (E.P.) —0.12

E.P. = Electrical psychrometer.

The dry-bulb and wet-bulb readings of the points of 90 per cent and 40 per cent relative humidity taken from the preliminary chart for each effective temperature line were corrected to Assmann readings.

Correction of i Constant Lines on the Mollier Diagram to Assmann Wet-Bulb Lines: In theory it is assumed that all the heat used in evaporating the water from the cloth surrounding the wet-bulb, is provided by the air layer, immediately enveloping the wet-bulb. In practice, however, this theoretical ideal cannot be reached because of the effect of heat-radiation from the surrounding surfaces on the wet-bulb. The effect of radiation on the wet-bulb is diminished in the aspiration psychrometers by ventilating the thermometers. This effect can be further diminished by shielding the thermometer bulbs, especially by using highly polished metal surfaces, which have a very low emission coefficient for radiant heat. It has been found experimentally, that the Assmann psychrometer in which the thermometer bulbs are shielded most effectively from radiation effect, gives the closest approximation to the theoretical wet-bulb.

The relationship between the actual water-vapor pressure and the theoretical wet-bulb values is contained in the following equation (see Wiesebron[7]):

$$p_d = p_{wt} - \frac{B.c_p}{0.622r}\left(1 - \frac{p_{wt}}{B}\right)\left(1 + 0.19\,\frac{p_d}{B}\right)(t - t_{wt}) \quad \ldots\ldots (3)$$

or in terms of psychrometric depression:

$$\frac{p_{wt} - p_d}{t - t_{wt}} = \frac{B.c_p}{0.622r}\left(1 - \frac{p_{wt}}{B}\right)\left(1 + 0.19\,\frac{p_d}{B}\right) \quad \ldots\ldots (3a)$$

$0.19\,\frac{p_d}{B}$ being small, Equation 3*a* can be written:

$$\frac{p_{wt} - p_d}{t - t_{wt}} = \frac{B.c_p}{0.622r}\left(1 - \frac{p_{wt}}{B}\right) \quad \ldots\ldots (3b)$$

For $p_d = O$ this equation reads

$$\frac{p_{wt}}{t - t_{wt}} = \frac{B.c_p}{0.622r}\left(1 - \frac{p_{wt}}{B}\right) \quad \ldots\ldots (3c)$$

without any approximations being made.

p_d = water-vapor pressure of the air in mm Hg.

p_{wt} = maximum water-vapor pressure at the theoretical wet-bulb temperature.

t = dry-bulb temperature.

t_{wt} = theoretical wet-bulb temperature.

B = barometric pressure (700 mm for Bandoeng).

c_p = specific heat of dry air = 0.24.

r = heat of evaporation of water in kcal/kg at a temperature t_{wt}.

Table 4—Lines of Best Fit for Each Subject

Subject	n	$\bar{x}$	$\bar{y}$	B	r	Line of Best Fit
Ke.....	34	17.59	21.76	1.327	0.281	$y = 1.327\,x - 1.58$
Soen....	31	12.30	23.66	— 17.11	— 0.04	$y = 234.11 - 17.11\,x$
Ki.....	91	21.64	22.78	0.408	0.661	$y = 0.408\,x + 13.95$
Co.....	75	18.80	22.79	0.737	0.504	$y = 0.737\,x + 8.93$
Ve.....	28	14.58	22.24	1.819	0.237	$y = 1.819\,x - 4.28$
Soet....	26	17.99	21.05	5.045	0.092	$y = 5.045\,x - 69.72$
Th.....	27	16.91	22.30	12.667	0.031	$y = 12.67\,x - 191.95$
Dj.....	26	17.08	23.63	— 6.931	— 0.062	$y = 142.0 - 6.93\,x$
Ka.....	24	20.55	22.10	1.202	0.370	$y = 1.2\,x - 2.56$
Kh.....	35	15.56	21.52	— 3.180	— 0.136	$y = 71 - 3.18\,x$
La.....	31	15.70	23.57	— 1.445	— 0.341	$y = 46.26 - 1.445\,x$
Si.....	38	17.00	22.12	3.607	0.097	$y = 3.607\,x - 39.2$
Soed....	39	15.14	23.25	1.550	0.322	$y = 1.55\,x - 0.22$
Kl.....	14	18.67	23.16	0.384	0.704	$y = 0.384\,x + 15.99$
Sch.....	34	15.88	22.42	— 3.934	0.117	$y = 84.89 - 3.934\,x$
Ho.....	38	18.26	22.75	— 2.002	0.310	$y = 59.31 - 2.002\,x$
Ba.....	13	22.85	22.36	— 10.117	— 0.057	$y = 253.53 - 10.117\,x$
Schsr....	12	20.60	23.38	3.703	0.075	$y = 3.7\,x - 52.84$
Bau.....	23	18.33	23.53	4.803	0.120	$y = 4.8\,x - 64.45$
Scha....	14	16.04	22.28	0.816	0.398	$y = 0.816\,x + 9.19$
Wi.....	34	28.72	23.24	0.458	0.497	$y = 0.458\,x + 10.09$

n = number of Equal Comfort Lines.
$\bar{x}$ = mean value of angle.
$\bar{y}$ = mean Effective Temperature.
B = tan. slope of Line of Best Fit.
r = correlation coefficient between Effective Temperature and angle subtended.

Table 5—Angles Used Corresponding to Effective Temperatures

E. T. (y) Deg C	Angle (x)
17	14.94
18	15.49
19	16.04
20	16.59
21	17.14
22	17.69
23	18.25
24	18.80
25	19.35
26	19.90
27	20.45
28	21.00
29	21.56

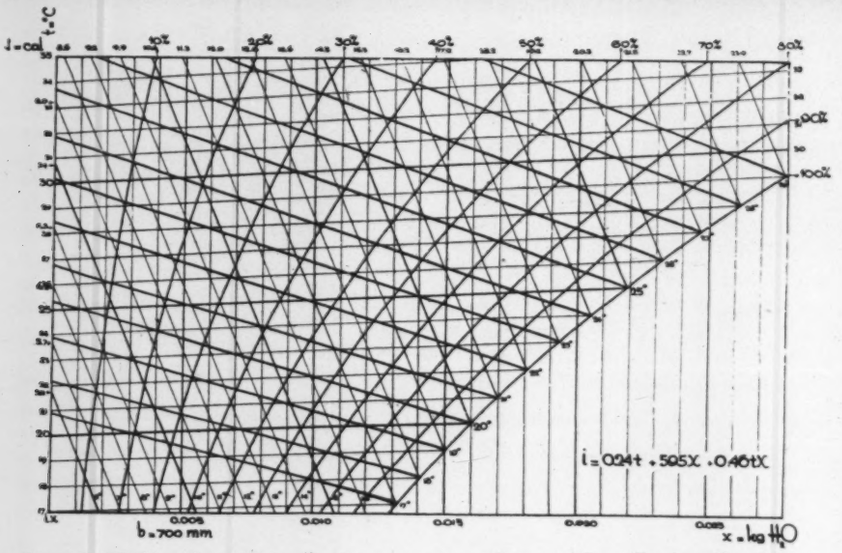

Fig. 10—Mollier chart with effective temperature Lines of Best Fit for all subjects

$0.622 = \frac{0.804}{1.293}$ = ratio between the weight of H_2O-vapor and of dry air under the same conditions.

The value

$$\frac{B.c_p}{0.622r}\left(1 - \frac{p_{wt}}{B}\right)$$

is the psychrometric constant P_t.

However, p_{wt} is variable and in consequence $\frac{p_{wt}}{B}$ is also variable, but this last value is only small in comparison with 1 so that the term $(1 - \frac{p_{wt}}{B})$ may be regarded as being approximately constant.

So Equation (3*b*) can be written as:

$$\frac{p_{wt} - p_d}{t - t_{wt}} = P_t \quad \ldots\ldots\ldots\ldots (4)$$

or if $p_d = 0$,

$$\frac{p_{wt}}{t - t_{wt}} = P_t \quad \ldots\ldots\ldots\ldots (4a)$$

The values of the theoretical psychrometric constant (P_t) are calculated from the Equation (3*b*) and are given in Table 6 which also includes the Assmann psychrometric constant (P_a) and the electrical psychrometric constant (P_e) found experimentally in a previous investigation. Thus, the relationship between the psychrometric depression recorded by the Assmann psychrometer and the difference between maximum wet-bulb vapor-pressure and actual vapor-pressure is expressed by the equation:

$$\frac{p_{wa} - p_d}{t - t_{wa}} = P_a \quad \ldots\ldots\ldots\ldots (5)$$

or if $p_d = O$

$$\frac{p_{wa}}{t - t_{wa}} = P_a \quad \ldots\ldots\ldots\ldots (5a)$$

wherein:

p_{wa} = maximum water vapor pressure at the Assmann wet-bulb temperature.

t_{wa} = Assmann wet-bulb temperature.

In order to be able to draw the Assmann wet-bulb lines on the Mollier diagram the stated relationship between water vapor pressure and wet-bulb temperature must be converted into one between x values and wet-bulb values. By doing so for the theoretical wet-bulb values by substituting x values for p values according to Equation (2) Equation (3*b*) can be written:

$$\frac{x_w(B - p_w) - x_d(B - p_d)}{(t - t_w)\,0.622} = \frac{B.c_p}{0.622r}\left(\frac{B - p_w}{B}\right) \quad \ldots\ldots (6)$$

For absolutely dry air $p_d = o$ and $x_d = o$. In that case $x_d\,(B - p_d) = o$, and the formula becomes

$$\frac{x_w}{t - t_w} = \frac{c_p}{r} \quad \ldots\ldots\ldots (6a)$$

This formula can also be derived from the equation to the Mollier diagram. As is stated previously this diagram is constructed according to the formula,

$$i = 0.24t + 595x + 0.46tx \ldots . (1)$$

For the theoretical wet-bulb line, the heat content of the point of intersection with the vertical axis (the index 1 refers to this point) is:

$$i_1 = 0.24t_1;$$

the heat content of the point of intersection with the saturation line is:

$$i_w = 0.24t_w + 595x_w + 0.46t_w x_w.$$

The constant i-line intersecting the saturation line at 0 C and the theoretical wet-bulb line of 0 deg are the same.

For higher wet-bulb temperatures, however, the slope (measured from the horizontal) of the wet-bulb line is less than that of the constant i-line passing through the point of intersection of the considered wet-bulb line with the saturation line.

This difference is proportional to the wet-bulb temperature. This will be clear if one remembers that the heat content of water of 0 C is considered in this diagram as being 0 kcal/kg. For water at the temperature of the wet-bulb higher than 0 C, 1 kg of water has a heat content expressed in kcal/kg, equal to the value of the wet-bulb temperature in C.

If water which has in itself a certain heat capacity is evaporated into air, the heat content of this water will be brought into the air-water-vapor mixture so formed, resulting in an increase in the heat content of the mixture.

Thus the heat content of mixtures lying on a wet-bulb line will increase in proportion to the absolute humidity.

$i_w - i_1 = 0.24\,(t_w - t_1) + 595x_w + 0.46t_w x_w = t_w x_w$ so that

$$\frac{t_1 - t_w}{x_w} = \frac{595 - 0.54t_w}{0.24} \quad \ldots\ldots\ldots (6b)$$

This equation is a special case of the general Equation (6).

By combining Equations (4*a*) and (6*b*) the result is:

$$t_1 - t_{wt} = \frac{p_{wt}}{Pt} = \frac{595 - 0.54t_{wt}}{0.24} x_w \ldots (7)$$

Now considering a theoretical wet-bulb line and an Assmann wet-bulb line through the same point of intersection with the saturation line,

$t_a - t_{wa} = \frac{p_{wa}}{P_a}$ because $t_{wa} = t_{wt}$ and $p_{wa} = p_{wt}$.

$(t_1 - t_w)\,P_t = (t_a - t_{wa})\,P_a$ and $(t_1 - t_{wt}) = \frac{(t_a - t_{wa})\,P_a}{P_t}$.

Consequently:

$$\frac{595 - 0.54t_{wa}}{0.24} x_w = (t_a - t_{wa})\frac{P_a}{P_t} \ldots (8)$$

and

$$\frac{(t_a - t_{wa})}{x_w} = \frac{595 - 0.54t_{wa}}{0.24}\cdot\frac{P_t}{P_a} \quad \ldots . (8a)$$

From this formula the point of intersection of the Assmann wet-bulb line with the vertical axis can be calculated. The Assmann wet-bulb lines can be drawn through this point and the point of intersection of the isotherm with the saturation line.

Table 6—Psychrometric Correction Constants

Wet-Bulb Deg C	P_t	P_a	P_e	P_w (m.m. Hg)	r
10	0.452	0.46	0.53	9.21	589.6
11	0.452	0.46	0.53	9.84	589.1
12	0.452	0.46	0.53	10.52	588.5
13	0.452	0.46	0.53	11.23	588.0
14	0.452	0.46	0.53	11.99	587.4
15	0.452	0.46	0.53	12.79	586.9
16	0.452	0.46	0.53	13.63	586.4
17	0.451	0.46	0.53	14.53	585.9
18	0.451	0.46	0.53	15.48	585.4
19	0.451	0.46	0.53	16.48	584.9
20	0.451	0.46	0.53	17.54	583.8
21	0.451	0.46	0.53	18.66	583.2
22	0.450	0.46	0.53	19.83	582.7
23	0.450	0.46	0.53	21.07	582.1
24	0.449	0.46	0.53	22.38	581.6
25	0.449	0.46	0.53	23.76	581.1
26	0.448	0.46	0.53	25.22	580.5
27	0.447	0.46	0.53	26.75	580.0
28	0.446	0.46	0.53	28.36	.....

The angle made by the Assmann wet-bulb line with the horizontal is calculated from the relationship:

$$\tan \infty = \frac{t_a - t_w - 0.46 t_w x_w}{x_w} \quad \ldots\ldots (9)$$

This equation gives x in kg H_2O cases where only one of the points of intersection of the Assmann line is on the part of the diagram constructed. In those cases, however, in which neither of these points lies on the diagram other points of the line must be calculated.

Then the x value of the point of intersection of the required Assmann wet-bulb line with an isotherm t is calculated as follows. According to Fig. 11:

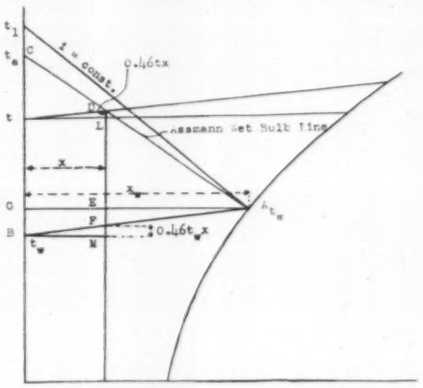

Fig. 11—Chart showing required point of intersection of Assmann wet-bulb line

$$\frac{BC}{AG} = \frac{DF}{AE}$$

$$\frac{0.24\,(t_a - t_w)}{x_w} = \frac{(0.24t + 0.46tx) - (0.24t_w + 0.46t_w x)}{x_w - x} \quad \ldots\ldots (10)$$

Combining the Equations (8*a*) and (10):

$$(595 - 0.54t_w)\,\frac{P_t}{P_a} = \frac{(0.24t + 0.46t_x) = (0.24t_w + 0.46t_w x)}{x_w - x} \quad \ldots\ldots (11)$$

from which:

$$x = \frac{x_w\,(595 - 0.54t_w)\,\dfrac{P_t}{P_a} - 0.24\,(t - t_w)}{(595 - 0.54t_w)\,\dfrac{P_t}{P_a} + 0.46\,(t - t_w)} \quad \ldots\ldots (12)$$

This equation gives x in kg H_2O per kcal dry air-water-vapor mixture. Fig. 10 is corrected by using Equations (8), (9) and (12). From the Mollier chart showing the effective temperature lines for all subjects (Fig. 10) the data as shown in Table 7 were obtained.

By using these data *Assmann-Corrected* effective temperature lines could be drawn on an *Assmann-Corrected* Mollier chart, showing true Assmann wet-bulb lines, and the slope of the effective temperature lines calculated in Table 8.

Assuming a straight line function:

$y = 2.13x - 15.3$ where

y = effective temperature in deg C.

x = slope of the effective temperature line in deg

Using this formula the final graph, Fig. 12, was constructed from the data shown in Table 9.

Comparison of Results with Those Found by American Investigators: Effective temperatures for dry- and wet-bulb temperatures situated in both dry (relative humidity < 50 per cent) and wet (relative humidity > 70 per cent) zones throughout the range from 17 C to 28 C, were calculated according to the effective temperature chart applicable to inhabitants of the U.S.A.[11], normally clad and engaged in light work. These effective temperatures were compared with those obtained for subjects clad in light tropical clothing in Netherlands India, the comparison being given in Table 10. From this table it is evident that, in terms of the Mollier diagram, the lines of effective temperature obtained by the American investigators subtend a somewhat greater angle to the horizontal than those obtained by those in Netherlands India. The difference is greatest at higher temperatures.

In the same Mollier diagram is also drawn the comfort zone for Netherlands India, established previously (see references 6 and 7). This figure may illustrate the remarks concerning *real comfort* and *effective temperature comfort* previously given in this paper.

Summary

1. A representative group of the population, forming 21 persons, served as subjects in an investigation into the effective temperature scheme for Netherlands India. The observations were carried out in still air and the subjects were clad in ordinary tropical clothing.

2. Use was made of the Mollier chart and the effective temperature lines or lines of equal comfort were superimposed on it.

3. The Assmann psychrometer was taken as standard both for dry-bulb and wet-bulb temperatures and the more convenient electrical psychrometric readings made during the investigation were converted thereto.

4. Assmann psychrometric wet-bulb lines were drawn on the Mollier diagram and use was made of the *Assmann* readings to determine the final slope of the effective temperature lines.

5. A Mollier chart is shown with effective temperature lines and comfort zone for Netherlands India.

6. A comparison is made between the effective temperature scheme for U.S.A. and that found in the present experiments for Netherlands India.

Acknowledgment

One of the authors, R. Courtice (Queensland University Science Graduate, Brisbane, Australia) wishes to express his gratitude to

Table 8—Slope of Corrected Effective Temperature Lines

D.B.T.	W.B.T.	D.B.T.	W.B.T.	E.T.	Slope
20.10	11.88	18.02	17.10	17.72	15°.50
33.32	24.06	29.51	28.13	28.80	20°.7

Table 7—Data from Mollier Diagram in Fig. 10

40 Per cent Relative Humidity					90 Per cent Relative Humidity				
E.T.	D.B.T.	W.B.T.	Assmann Corrected Readings		E.T.	D.B.T.	W.B.T.	Assmann Corrected Readings	
			D.B.T.	W.B.T.				D.B.T.	W.B.T.
18 C	20.25	12.33	20.10	11.88	18 C	18.33	17.22	18.02	17.10
29 C	33.47	24.51	33.32	24.06	29 C	29.82	29.25	29.51	28.13

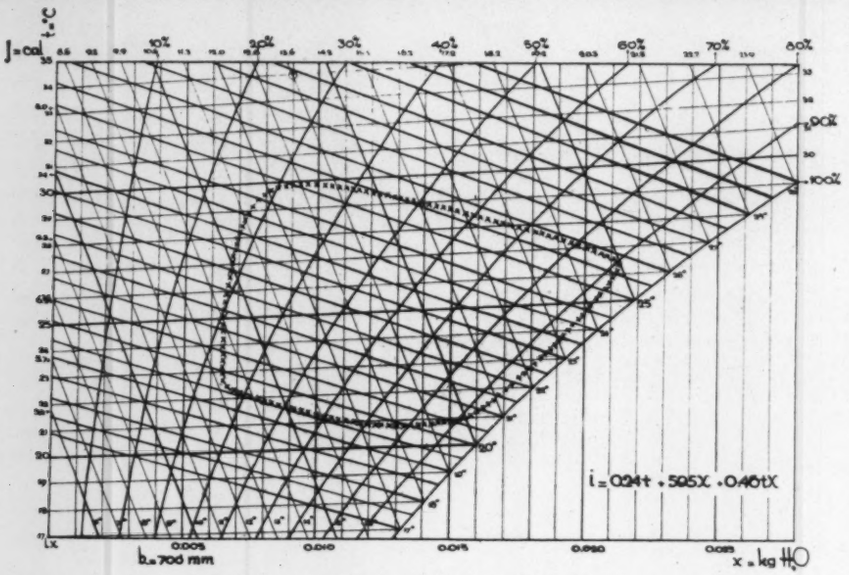

Fig. 12—Final graph (Assmann Readings)

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Table 9—Data Final Graph (Fig. 12)

E.T. Deg C	Angle Deg	E.T. Deg C	Angle Deg
17.0	15.16	23.5	18.22
17.5	15.40	24.0	18.45
18.0	15.63	24.5	18.69
18.5	15.87	25.0	18.92
19.0	16.10	25.5	19.16
19.5	16.34	26.0	19.39
20.0	16.57	26.5	19.62
20.5	16.81	27.0	19.86
21.0	17.04	27.5	20.09
21.5	17.28	28.0	20.33
22.0	17.51	28.5	20.56
22.5	17.75	29.0	20.80
23.0	17.90	29.0	20.80

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Table 10—Effective Temperature Comparison Between Results Obtained in U. S. A. and Netherlands, India

Dry (Relative Humidity < 50 Per Cent)					Wet (Relative Humidity > 70 Per Cent)				
Dry-Bulb	Wet-Bulb	E.T. American	E.T. Neth. India	Diff. (E.T.) (N.I.-A.)	Dry-Bulb	Wet-Bulb	E.T. American	E.T. Neth. India	Diff. (E.T.) (N.I.-A.)
19.0	14.0	17.4	17.5	+ 0.1	18.0	15.0	17.1	17.1	0.0
20.0	14.0	18.1	18.2	+ 0.1	18.0	17.0	17.7	17.7	0.0
20.0	15.0	18.3	18.4	+ 0.1	19.0	18.0	18.7	18.7	0.0
21.0	15.0	18.8	19.1	+ 0.3	20.0	18.0	19.3	19.3	0.0
22.0	16.0	19.7	20.0	+ 0.3	21.0	19.0	20.1	20.25	+ 0.15
23.0	17.0	20.7	20.95	+ 0.25	22.0	20.0	21.1	21.2	+ 0.1
24.0	17.0	21.2	21.5	+ 0.3	23.0	20.0	21.7	21.8	+ 0.1
25.0	18.0	21.9	22.4	+ 0.5	24.0	21.0	22.7	22.8	+ 0.1
26.0	17.0	22.1	22.7	+ 0.6	25.0	22.0	23.6	23.75	+ 0.15
27.0	18.0	22.9	23.5	+ 0.6	26.0	24.0	24.9	25.1	+ 0.2
28.0	18.0	23.4	24.1	+ 0.7	27.0	25.0	25.9	26.1	+ 0.2
29.0	19.0	24.2	24.8	+ 0.6	28.0	26.0	26.7	27.0	+ 0.3
30.0	19.0	24.6	25.3	+ 0.7	29.0	26.0	27.2	27.5	+ 0.3
31.0	20.0	25.4	26.2	+ 0.8	29.0	28.0	28.3	28.5	+ 0.2
32.0	20.0	25.8	26.7	+ 0.9					
33.0	21.0	26.5	27.6	+ 1.1					
34.0	21.0	26.8	27.9	+ 1.1					

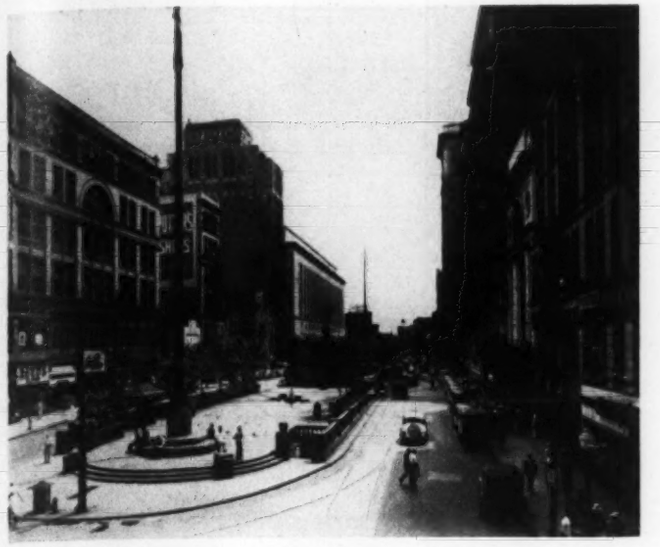
SOUTHERN CALIFORNIA WITNESSES BOMBING OF PEARL HARBOR

June 11. The Southern California Chapter of the Society held its June meeting at Eaton's Chicken House, and 90 members and guests were present. The meeting was preceded by a social hour, which proved so successful that it was decided to precede each meeting with a get-together.

Pres. A. J. Hess called the meeting to order and the minutes of the previous meeting were read and approved. It was brought out at this meeting that the average attendance for the past two years was 51, which was an increase over the past few years. Following a report by the treasurer, President Hess installed the newly elected officers for the year 1942-43.

The meeting was then turned over to H. H. Bullock, who showed a comedy motion picture sound film, followed by another sound film entitled *Blitzkrieg*. This latter film was shown by Frank Meredith, former Signal Corps photographer of the 26th Yankee Division, who explained that this film will not be shown to the general public. It showed actual scenes of the bombing of Pearl Harbor, fighting in the Philippines and the siege of Singapore. It was a real privilege for the members of the Southern California Chapter to witness the showing of this film.

An Invitation from Cincinnati



Fountain Square

COMMITTEE ON ARRANGEMENTS
49TH ANNUAL MEETING, ASHVE

Honorary Chairman	W. C. Greene
General Chairman	Albert Buenger
Vice Chairman	Amos Hard
Secretary	George Sutfin
Finance	W. H. Junker
Publicity	K. Wright
Ladies	Mrs. G. B. Houliston
Banquet	Harry Pillen
Entertainment	Geo. B. Houliston
Reception	H. E. Sproull
Transportation	A. E. Edwards

MEMBERS OF the Society will assemble in Cincinnati for the 49th Annual Meeting, January 25-27, 1943, in Hotel Gibson, according to plans announced by Pres. Amos Hard and the Committee on Arrangements of the local chapter which will be hosts for the occasion. The theme of the meeting will harmonize with the war effort and numerous subjects on the technical program will provide basic data for those who must solve the new problems in heating, ventilating, and air conditioning that have developed with the war program.

Fuel conservation will have a prominent place in the discussions. This subject is of wider significance now that fuel oil rationing has been announced for the 30 eastern and middle-western states.

Research work that has contributed to the progress of war production will be included in the reports of investigations now under way. Living under wartime conditions which influence comfort, efficiency, and health is of vital importance to the engineering profession dealing with heating, ventilating, and air conditioning. What engineers in this field are doing to help win the war is a fascinating topic.

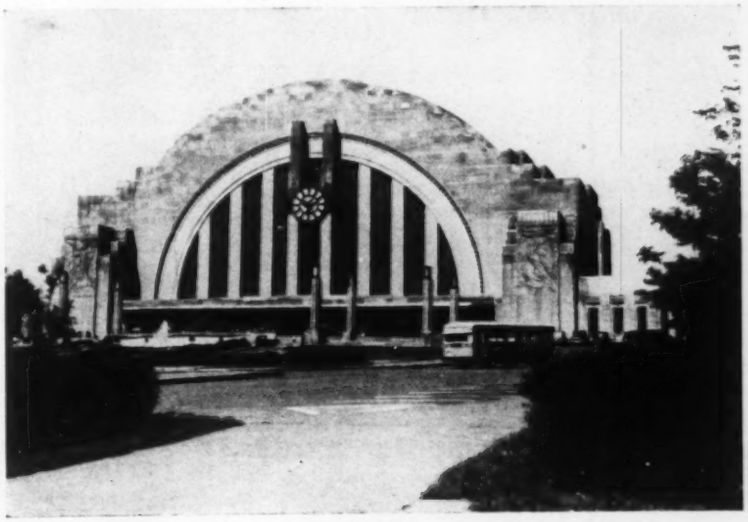
The preliminary outline of the meeting program provides for an opening luncheon with a speaker of national prominence, four technical sessions for reports, papers and discussions, the annual banquet, and a program of special ladies' events, according to Kenneth Wright, publicity chairman.

The Committee on Arrangements, under the direction of Albert Buenger, has held several meetings and sends a cordial invitation to all ASHVE members to come to Cincinnati. Many of the committee chairmen served during the Society's meeting 10 years ago and are preparing for your pleasure, headed by Honorary Chairman William C. Greene. Howard Sproull will head the Reception Committee and the Entertainment and Ladies programs will be directed respectively by Mr. and Mrs. George B. Houliston.

Cincinnati is called the Queen City and is the gateway to the South, an important railroad center and river port. Its Union Terminal cost $43,000,000 and is one of the most modern and most beautiful in the world. Citizens are justly proud of its reputation as a music and art center. The Tyler Davidson Fountain, presented to the city in 1871, is considered one of the finest groups of statuary in the world.

The diversity of its industries is impressive and the war has emphasized the fact that Cincinnati ranks as the machine tool center of America, and is the world's largest producer of soap and playing cards. It is a leading meat packing center, produces laundry machinery, printing inks, books, boots and shoes, clothing, drugs, pianos, pottery and glass, auto parts, and airplanes.

The city proper has an area of nearly 75 square miles; its population is about 500,000 and that of the surrounding metropolitan area is 790,000. Cincinnati was named in 1790 by Gen. Arthur St. Clair, governor of the Northwest Territory, in honor of the Society of the Cincinnati, an organization of Revolutionary War officers.



Union Station

NOMINATIONS FOR 1943

Nominations for Officers and Council

The Nominating Committee appointed to select candidates for Officers of the Society for the coming year, 1943, submits the following list of nominees:

For President:

M. F. BLANKIN, Philadelphia, Pa.

For First Vice-President:

S. H. DOWNS, Kalamazoo, Mich.

For Second Vice-President:

C.-E. A. WINSLOW, New Haven, Conn.

For Treasurer:

E. K. CAMPBELL, Kansas City, Mo.

For Members of the Council:

Three-Year Term

J. F. COLLINS, JR., Pittsburgh, Pa.

JAMES HOLT, Cambridge, Mass.

E. N. MCDONNELL, Chicago, Ill.

T. H. URDAHL, Washington, D. C.

Respectfully submitted,

NOMINATING COMMITTEE,
M. W. BISHOP, *Chairman.*

In accordance with the provisions of the Society's Constitution, By-Laws and Rules, ballots containing the names of the above candidates will be sent to the membership for voting upon prior to the Annual Meeting in January.

Art. B-VIII—Section 11. The Nominating Committee shall consist of one (1) member eligible to vote designated by each Chapter, or his alternate also appointed by the Chapter. The Secretary of each Chapter shall certify to the Secretary of the Society on or before January first the names of the member and alternate selected.

The Committee shall meet at the Annual Meeting of the Society at the call of the Secretary of the Society and shall effect its own organization and elect its own Chairman. At the Semi-Annual Meeting of the Society, if possible, the Nominating Committee shall select the nominees for the ensuing year for the offices of President, First Vice-President, Second Vice-President, Treasurer, and four (4) members of the Council. In any event the names of the nominees shall be certified to the Secretary of the Society before September twentieth, with the written consent of each nominee to fill the office for which he has been selected and their names with the offices to which they have been nominated shall be published in the October issue of the JOURNAL.

Art. B-IX—Section 2. The Secretary shall prepare ballots with the names of all candidates and forward them to the members, eligible to vote, at least thirty (30) days before the date of the Annual Meeting.

Nominations for Members of Committee on Research

Although committees of the Society are usually appointed, in view of the great importance of the Committee on Research and the financial responsibility it would be called upon to assume, it has been made more representative of the entire membership of the Society by a process of *election*. The election is governed by the By-Laws for the election of officers, with the single exception that Members of the Committee on Research are nominated by the Council instead of by a Nominating Committee.

In accordance with the Regulations for the Government of the Research Laboratory, the Council announces the nomination of the following members of the Committee for election to succeed those members whose present terms expire January, 1943.

Three-Year Term

H. J. ROSE, Pittsburgh, Pa.

L. P. SAUNDERS, Lockport, N. Y.

L. E. SEELEY, New Haven, Conn.

A. E. STACEY, JR., Washington, D. C.

C. TASKER, Toronto, Ont., Canada

The regulations governing the nomination and election of members of the Committee on Research are as follows:

ARTICLE II—ORGANIZATION

Section 1. *Committee on Research*—There shall be a standing committee known as the Committee on Research, consisting of fifteen (15) members each serving for three (3) years and five (5) retiring each year. The outgoing Chairman if serving in that capacity during the last year of his three (3) year term on the Committee shall without election become an additional member of the Committee on Research for one (1) year.

(*a*) The Council shall nominate previous to July first of each year five (5) members to fill the vacancies of those retiring at the next Annual Meeting.

(*b*) The nominations made by the Council shall be published in the October issue of the Society's JOURNAL.

(*c*) Any ten (10) members of the Society eligible to vote may present to the Secretary over their signatures, the name of one (1) or more additional nominees for the Committee on Research, provided such name or names are presented at least sixty (60) days prior to the next Annual Meeting, and such additional nominations shall be placed on the ballot opposite the nominations made by the Council.

(*d*) The election shall otherwise conform to the regulations provided for the election of officers of the Society in the Constitution, By-Laws and Rules.

(*e*) Vacancies may be filled by the Council, such persons chosen by the Council to serve until a successor is elected at the next Annual Meeting.

DR. ALICE BRYANT, LIFE MEMBER, DIES

Dr. Alice G. Bryant, one of the first woman ear, nose and throat specialists in the country and a Life Member of the Society, died July 25, 1942, at Palmer Memorial Hospital, after an illness of six weeks. She was 80 years of age.

Born in Boston on April 27, 1862, Dr. Bryant received her early education from her parents and from private tutors, as well as at the Henry Williams' Private School. She attended Vassar College, receiving her A.B. from there in 1885, followed by one year of technology instruction at M.I.T. She then spent three years at the Woman's Medical College of Pennsylvania, another year at M.I.T., and a year at the Woman's Medical College, New York Infirmary, where in 1890 Dr. Bryant received her M.D. For her internship she returned to Boston to the New England Hospital for Women and Children.

From that point on it is difficult to give a chronological account, as Dr. Bryant worked so tirelessly—studying, teaching, conducting clinics, writing, inventing, and acting as consultant, the specialities which coordinated all this activity being otology and laryngology. She was one of the first to hold evening clinics in her specialty.

She was associated with the Vincent Memorial Hospital and the New England Hospital for Women and Children, also of Boston, and was a member of the courtesy staff, and later of the associate staff of the New England Deaconess Hospital. She also spent some time as guest worker at Bellevue, Gouverneur and Willard Hospitals in New York City, and at the German and Blockley Hospitals in Philadelphia.

She joined the Society in 1921, and was elected to Life Membership by the Council at the 42nd Annual Meeting of the Society in Chicago in 1936. She was also a member of the *IES,* a fellow of the *American College of Surgeons,* a fellow of the *Royal Institute of Public Health and Hygiene,* a fellow of the *Royal Astronomical Society,* and an associate of *Engineering Economics,* as well as being associated with 50 other scientific and humanitarian societies.

She was on the Massachusetts governing committee of the Gorgas Memorial Institute of Tropical and Preventive Medicine, and in 1931 was substitute for the commissioner of education in Massachusetts for the Dalgren Prize contest sponsored by that institute.

Dr. Bryant is survived by a sister, Miss Grace Bryant of Woburn, Mass., to whom the Officers and Council of the Society extend their deepest sympathy. Dr. Bryant's death is a great loss to the heating and ventilating profession, and her loss will be keenly felt by her host of friends and associates in the field.

PTL LOSES M. L. CARR

A well-known man in the research field, with a wide circle of friends in the Society, passed away July 13, when Maurice L. Carr, Director of Research at Pittsburgh Testing Laboratories, died at the age of 65.

Mr. Carr was born at Avon, Ill., April 17, 1877, and was graduated

M. L. Carr

from the local high school, receiving his degree of B.S. in 1905 from the University of Illinois and his E.E. in 1911.

His first job was as a telephone line and instrument man, after which he became a meter tester for the Peoria Gas and Electric Co. Then for two years he was a High School Instructor, and after finishing college, he was Research Assistant at the University of Illinois Engineering Experiment Station in the Physics Department. From 1907 to 1920 he was with the Underwriters' Laboratories, Chicago, in charge of testing building materials, during which period he devised many test procedures. From 1920 to 1926 he directed the research work of the Safe-Cabinet Co., Marietta, Ohio, and then became a consultant for Remington-Rand Co. on fire protection problems.

In 1930 he joined the staff of the Pittsburgh Testing Laboratories and specialized on heat and sound insulating properties of building materials.

Mr. Carr joined the Society in 1931, and he also belonged to the *AIEE, ASME, ASTM, American Physical Society* and *Western Society of Engineers.* He also was a member of the *National Fire Protection Association* and the *American Association for Advancement of Science* and the *Acoustical Society of America.* He belonged to the Veterans of the Spanish-American War, having served in the 6th Illinois Infantry. He served as Chairman of several ASHVE Research Technical Advisory Committees, and at the time of his death was Chairman of the Committee on Air Conditioning Requirements of Glass. In 1937 he served as President of the Pittsburgh Chapter of the Society.

In paying tribute to Mr. Carr, the president of the Pittsburgh Testing Laboratories, A. R. Ellis, said:

"Entirely aside from his value to our organization, he earned the respect and admiration of everyone through his willingness to tackle difficult jobs and to bring them to a successful conclusion, and for his unfailing cheerfulness and always present sense of humor when the going at times must have been heavy for him.

"We shall miss him a lot, but our loss will be tempered by the knowledge that he was happy in what he was doing. We have lost a friend and an associate whose replacement will be difficult, and one who devoted most of his time and thought to our welfare."

Mr. Carr is survived by two sisters, the Misses Fannie and Dorothy Carr, who live in Avon, Ill., to whom the Officers and Council extend their sincere and heartfelt sympathy.

DEATH OF ALFRED E. SEELIG

Alfred E. Seelig, president and general manager of L. J. Wing Mfg. Co., New York, died suddenly, September 13, at his home, 640 Riverside Drive, at the age of 54.

Mr. Seelig had been associated with L. J. Wing Mfg. Co. for 26 years, in the production of fans and blowers for ventilating and forced draft work.

He was born on October 6, 1887 in New York City where he received

his early education. He received his degree in electrical engineering from Columbia University in 1907, after which he joined the staff of J. G. White Engineering Corp., and later was with Crocker Wheeler Co. In 1910 he became New England representative for L. J. Wing Mfg. Co., and in 1911 was appointed general sales manager. From 1912 to 1914 he was general manager of the Atlantic Communication Co., New York, and then became sales manager for the Kerr Turbine Co. Since 1917 he had been president of the L. J. Wing Company, and was one of the pioneers in the development of suspended unit heaters.

Mr. Seelig became a member of the Society in 1926 and took an active part in the work of its technical committees. He held membership in the *ASME, AIEE* and belonged to Tau Beta Pi fraternity.

Mr. Seelig is survived by his widow, Mrs. Lucille B. Seelig, and a son, Owen M. Seelig, to whom the Officers and Council of the Society express their sincere sorrow for the great loss they have sustained.

WALLACE M. HYMAN DIES SUDDENLY

The heating profession lost one of its leaders in the sudden death on August 30, of Wallace M. Hyman, president of Reis and O'Donovan, Inc., New York, N. Y. He died unexpectedly at his home.

Mr. Hyman was born in New York, January 19, 1881, and attended the public schools, including the College of the City of New York. He received his degree of E.E. from Columbia University. After completing his engineering training, he spent two years with the General Electric Co. in the testing department, and then became a draftsman for the New York Telephone Co. During the next five years he was on the staff of P. R. Moses, Consulting Engineer.

In 1909 he started with Reis and O'Donovan, Inc., in charge of the heating and ventilating department.

He joined the Society in 1920 and was also active in the membership of *Heating, Piping and Air Conditioning Contractors, New York City Association*. He was a member of the City Athletic Club and the Inwood Golf Club. He was also president of Kenmore Hall, a club hotel.

Mr. Hyman leaves a widow, Mrs. Miriam Haines Hyman, and a brother, Alfred H. Hyman of Rochester, N. Y., to whom the Officers and Council express their deepest sympathy.

Candidates for Membership

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 7 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge the members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by October 15, 1942, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
BEMIS, PAUL D., Owner, Paul D. Bemis, (Consulting Engr.), Hartford, Conn.	T. S. Hart	C. J. Lyons
BENSON, FOSTER W., Application Engr., Niagara Blower Co., Chicago, Ill.	W. K. Simpson	L. A. Teasdale
CORNELIUS, GEORGE E., Engr., Anthracite Industries Laboratory, Primos, Del. Co., Pa.	E. M. Mittendorff	A. J. Keating
DEVEREUX, JAMES K., Sales Mgr., Monroe Armature Works, Monroe, La.	A. L. Crump	R. M. Spencer
McMULLEN, ERNEST W., Partner, Ganteaume & McMullen, Boston, Mass.	A. J. Johnson	H. H. Mather
RAINEY, WALTON, Combustion Engr., Anthracite Industries Laboratory, Primos, Del. Co., Pa.	P. A. Mulcey	C. B. Eastman
SAWYER, HOWARD C., Sales Exec. & Partner, Sawyer-Hare Furnace Co., Detroit, Mich.	W. H. Dudley, Jr.	G. C. Kerr
	F. D. Graham	G. E. May
	J. W. Brinton	W. T. Jones
	C. R. Swaney	N. J. H. Shaw
	A. J. Johnson	H. H. Mather
	P. A. Mulcey	C. B. Eastman
	W. A. Hare	W. F. Tydings
	F. R. Bishop	E. B. Root

Candidates Elected

In the past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

BAECHLIN, ALFRED C., JR., Engr., Western Electric Co., Bayonne, N. J.

FULMOR, IRA P., Owner, Air Conditioning Co. of Southern California, Los Angeles, Calif.

O'DANIEL, JAMES A., Proprietor, Maple City Furnace Co., Monmouth, Ill.

OTT, M. EARL, Pres., Parkside Sheet Metal Works, Inc., Chicago, Ill.

STOTESBURY, BERNARD, Plumbing & Heating Contractor, W. G. Edge Ltd., Ottawa, Ont., Canada

ASSOCIATES

HOOPER, FREDERICK W., Vice-Pres., Ross Engineering of Canada Ltd., Montreal, Que., Canada

MEYERS, CARL F., Sales & Engrg., Coblentz Equipment Co., Erie, Pa.

WANGSGAARD, DEE, Proprietor, Wangsgaard Coal & Stoker Co., Logan, Utah

JUNIORS

BRYAN, WILLIAM L., JR., Research Engr., York Ice Machinery Corp., York, Pa.

KOLASA, MARION J., Engr., Gar Wood Industries, Detroit, Mich.

Officers, Council and Committees

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

51 Madison Ave., New York, N. Y.

OFFICERS

President.....E. O. EASTWOOD
First Vice-President.....M. F. BLANKIN
Second Vice-President.....S. H. DOWNS
Treasurer.....E. K. CAMPBELL
Secretary.....A. V. HUTCHINSON
Technical Secretary.....JOHN JAMES

COUNCIL

E. O. EASTWOOD, *Chairman* M. F. BLANKIN, *Vice-Chairman*

Three Years: L. G. MILLER, A. J. OFFNER, A. E. STACEY, JR., B. M. WOODS.

Two Years: A. P. KRATZ, W. A. RUSSELL, L. P. SAUNDERS, C. TASKER.

One Year: J. F. COLLINS, JR., W. L. FLEISHER, E. N. MCDONNELL, T. H. URDAHL, C.-E. A. WINSLOW, F. C. MCINTOSH, *Ex-Officio.*

COUNCIL COMMITTEES

Executive—W. L. Fleisher, *Chairman*, A. J. Offner, A. E. Stacey Jr.
Finance—E. N. McDonnell, *Chairman*, J. F. Collins, Jr., C.-E. A. Winslow.
Membership—W. A. Russell, *Chairman*, M. F. Blankin, B. M. Woods.
Standards—S. H. Downs, *Chairman*, L. G. Miller, C. Tasker.
Meetings—A. P. Kratz, *Chairman*, L. P. Saunders, T. H. Urdahl.

ADVISORY COUNCIL

W. L. Fleisher, *Chairman;* Homer Addams, D. S. Boyden, W. H. Carrier, S. E. Dibble, W. H. Driscoll, F. E. Giesecke, H. P. Gant, E. Holt Gurney, L. A. Harding, H. M. Hart, C. V. Haynes, E. Vernon Hill, John Howatt, W. T. Jones, D. D. Kimball, G. L. Larson, S. R. Lewis, Thornton Lewis, J. F. McIntire, F. B. Rowley and A. C. Willard.

SPECIAL COMMITTEES

Admission and Advancement—Earle W. Gray, *Chairman* (*one year*); E. P. Heckel (*two years*), T. T. Tucker (*three years*).

ASHVE-*ASTM-ASRE-NRC Committee on Thermal Conductivity:* F. C. Houghten, *Chairman;* C. B. Bradley, H. C. Dickinson, R. H. Heilman, E. R. Queer, F. B. Rowley, T. S. Taylor and G. B. Wilkes.

ASHVE-IES Joint Committee on Lighting and Air Conditioning—H. M. Sharp, *Chairman*; W. R. Beach, B. C. Candee, W. G. Darley, C. L. Kribs, Jr., P. M. Rutherford, Jr.

Chapter Relations—J. F. Collins, Jr., *Chairman;* Lincoln Bouillon, M. M. Rivard.

Constitution and By-Laws—Albert Buenger, *Chairman*, L. T. Avery, R. H. Carpenter.

Committee on Code for Testing Surface Coils for Heating and Cooling—C. A. McKeeman, *Chairman;* Tom Brown, E. L. Hogan, H. F. Hutzel, L. E. Moody, A. F. Nass, S. F. Nicoll, M. Noble, L. P. Saunders, and D. C. Wiley.

Committee on Safety Regulations for Heating, Ventilating and Air Conditioning Systems—N. A. Hollister, *Chairman;* F. H. Buzzard, B. F. McLouth, G. P. Nachman, and C. H. Randolph.

Committee on ASHVE Code for Testing Air Cleaning Devices—John Howatt, *Chairman;* O. W. Armspach, J. L. Blackshaw, R. S. Dill, S. P. Eagleton, S. R. Lewis, Arthur Nutting, G. W. Penney, F. B. Rowley, J. H. Waggoner, and Dr. Leonard Greenburg, *Ex-Officio.*

Guide Publication—A. J. Offner, *Chairman*, P. D. Close, S. Konzo, C. S. Leopold, G. L. Tuve.

F. Paul Anderson Award—M. F. Blankin, *Chairman*, W. H. Carrier, J. D. Kroeker, J. F. McIntire, F. B. Rowley.

Joint Committee on Standards for Residence Heating—L. E. Seeley, *Chairman;* R. S. Dill, S. H. Downs, H. L. Dryden, J. G. Eadie, H. C. Meyer, Jr., R. K. Thulman, T. H. Urdahl, and H. Vermillyea.

Joint Committee to Study Uniform Methods of Heat Loss Calculation—P. D. Close, *Chairman;* A. P. Kratz, J. P. Magos, G. P. Nachman, A. F. Nass.

Joint Committee on Weather Statistics—J. F. Collins, Jr., *NDHA, Chairman;* F. H. Dewey, *OBI*, C. M. Humphreys, ASHVE, S. Konzo, *NWAHACA*, Raymond Little, *AGA*, Dr. E. Dillen Smith, *U. S. Weather Bureau.*

Publication—James Holt, *Chairman* (*one year*); C. H. B. Hotchkiss (*two years*), J. H. Walker (*three years*).

War Service Committee—B. M. Woods, *Chairman*, W. A. Danielson, W. L. Fleisher, E. Holt Gurney, Thornton Lewis, A. C. Willard.

NOMINATING COMMITTEE 1942

Chapter	*Representative*	*Alternate*
Atlanta	T. T. Tucker	A. H. Koch
Cincinnati	C. E. Hust	Albert Buenger
Connecticut	L. E. Seeley	Stanley Hart
Delta	L. V. Cressy	J. S. Adair
Golden Gate	**C. E. Bentley**	
Illinois	M. W. Bishop	E. M. Mittendorff
Iowa	Perry LaRue	F. E. Triggs
Kansas City	M. M. Rivard	W. A. Russell
Manitoba	R. L. Kent	I. McDonald
Massachusetts	J. W. Brinton	Earl G. Carrier
Michigan	J. S. Kilner	M. B. Shea
Minnesota	R. E. Backstrom	N. D. Adams
Montreal	A. M. Peart	E. W. Twizell
Nebraska	Henry Kleinkauf	W. R. White
New York	Joseph Wheeler, Jr.	H. H. Bond
North Carolina	W. M. Wallace II	F. J. Reed
North Texas	R. K. Werner	J. A. Bishop
Northern Ohio	C. A. McKeeman	C. M. H. Kaercher
Oklahoma	J. H. Carnahan	E. F. Dawson
Ontario	D. O. Price	H. R. Roth
Oregon	E. E. Carroll	B. W. Farnes
Pacific Northwest	H. T. Griffiths	M. J. Hauan
Philadelphia	H. H. Mather	
Pittsburgh	C. M. Humphreys	H. Lee Moore
St. Louis	C. F. Boester	J. H. Carter
South Texas	A. M. Chase, Jr.	R. M. Spencer
Southern California	A. J. Hess	H. H. Bullock
Washington, D. C.	F. A. Leser	T. H. Urdahl
Western Michigan	L. G. Miller	T. D. Stafford
Western New York	W. R. Heath	
Wisconsin	W. A. Ouweneel	D. W. Nelson

COMMITTEE ON RESEARCH

F. C. MCINTOSH, *Chairman*

C.-E. A. WINSLOW, *Vice-Chairman* F. C. HOUGHTEN, *Director*
J. H. WALKER, *Technical Adviser* A. C. FIELDNER, *Ex-Officio Member*

Three Years: C. F. BOESTER, J. A. GOFF, W. E. HEIBEL, C. A. MCKEEMAN, C.-E. A. WINSLOW.

Two Years: C. M. ASHLEY, M. K. FAHNESTOCK, H. KING MCCAIN, F. C. MCINTOSH, T. H. URDAHL.

One Year: PHILIP DRINKER, AXEL MARIN, A. E. STACEY, JR., J. H. VAN ALSBURG, J. H. WALKER.

Executive Committee: F. C. McIntosh, *Chairman;* C. M. Ashley, M. K. Fahnestock, T. H. Urdahl, C.-E. A. Winslow.

Finance Committee: C. F. BOESTER, *Chairman.*